INTERNATIONAL DECADE OF OCEAN EXPLORATION

PROGRESS REPORT : January 1970 to July 1972

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Prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, under contract to the National Science Foundation, Office for the International Decade of Ocean Exploration.

January 1973

PREFACE

The International Decade of Ocean Exploration (IDOE) is a long-term international, cooperative program to enhance utilization of the ocean and its resources for the benefit of mankind.

The IDOE was announced on March 8, 1968, when the President of the United States proposed "an historic and unprecedented adventure—an International Decade of Ocean Exploration for the 1970's." In December 1968, in Resolution 2414, the United Nations General Assembly endorsed "the concept of an international decade of ocean exploration to be undertaken within the framework of a long-term programme of research and exploration. . . ."

In late 1969, the Vice President of the United States, in his capacity as Chairman of the National Council on Marine Resources and Engineering Development, formally announced the United States intention to contribute to the IDOE and assigned responsibility for planning, managing, and funding the U.S. program to the National Science Foundation (NSF). In charging the NSF with this responsibility, the Vice President cited proposed goals relative to man's involvement with the oceans in three broad areas. These were:

- Determine the quality of the ocean environment through accelerated scientific observations of the ocean's natural state, evaluate the impact of man's activity on that environment, and establish a scientific basis for corrective actions necessary to preserve the ocean environment;
- Provide the scientific basis needed to improve environmental forecasting; and
- Assess the sea floor for its resource potential.

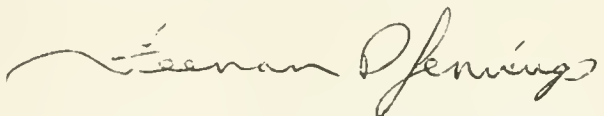
An additional program was added during Fiscal Year 1972 to:

- Provide the basic scientific knowledge of biological processes necessary to the intelligent utilization of living marine resources.

One further objective outlined by the Vice President was to:

- Improve worldwide data exchange through modernizing and standardizing national and international marine data collection, processing, and distribution.

In pursuit of this latter objective, the IDOE Office of NSF contracted with EDS of the National Oceanic and Atmospheric Administration to manage the scientific data for IDOE. The agreement included publishing this report, the first of a series.



Feenan D. Jennings, Head
Office for the International
Decade of Ocean Exploration

INTRODUCTION

This report provides the scientific community and other interested persons with information, data inventories, and lists of scientific reports pertinent to IDOE.

The text is arranged according to the program areas established for IDOE. Details on subprograms or projects are usually given under appropriate headings whenever possible; Seabed Assessment cruises, however, cross project lines. This report includes information on projects begun before 1970 and now funded by IDOE.

The Appendix contains the National Marine Data Inventory (NAMDI), a computerized summary of reported observations made at sea during the period covered by this Report. All IDOE grant holders must submit NAMDI or equivalent reporting forms, e.g. Cooperative Investigation of the Caribbean and Adjacent Regions Data Inventory (CICARDI), to the National Oceanographic Data Center (NODC). In this report the NAMDI's are arranged in the same project sequence as the text, but concern only the Environmental Quality, Environmental Forecasting, and Seabed Assessment Programs.

The chart inside the back cover shows ocean areas for which data, NAMDI forms, and track charts have been received by EDS. Areas are delinated by squares of 600 by 600 miles. Although an entire square is shaded on the chart, it may contain only one reported observation.

EDS either has the data, information, and papers described in this report in one of its center archives or knows where the data may be obtained.

Queries may be addressed to any of the following EDS centers:

National Oceanographic Data Center
National Oceanic and Atmospheric Administration
Rockville, Md. 20852

Environmental Science Information Center
National Oceanic and Atmospheric Administration
Washington, D.C. 20235

Marine Geology and Geophysics Group
National Geophysical and Solar-Terrestrial Data Center
National Oceanic and Atmospheric Administration
Washington, D.C. 20235

National Climatic Center
National Oceanic and Atmospheric Administration
Federal Building
Asheville, N.C. 28801

CONTENTS

Environmental Quality Program

The goal of the IDOE Environmental Quality Program is to learn whether serious damage has been done to marine organisms and marine ecosystems as a result of man's activities. A long-range program consisting of two studies has been initiated to investigate this complex problem: (1) the geochemical oceans sections study and (2) the study of baseline data, transport, and biological effects of pollutants in the ocean.

GEOCHEMICAL OCEAN SECTIONS (GEOSECS) STUDY

In the GEOSECS Study, water samples will be collected at many depths along north-south sections from the Arctic to the Antarctic. For the first time, a set of more than 20 physical and chemical parameters will be determined from each water sample. Information and data resulting from sample analysis will be used in quantitative studies of ocean mixing and organic productivity and in geochemical inventories—the major scientific goals of the program.

GEOSECS survey tracks through the Atlantic and Pacific Oceans will follow, as far as is now known, the approximate trajectory of the bottom water current. The research plan is to make chemical measurements at sea, when possible, and to complete analyses in shore laboratories. The Atlantic cruise will be conducted during July 1972 to March 1973; the Pacific cruise, during 1974.

The GEOSECS Study is composed of the following projects:

Organization	Investigator	Project Title
Atomic Energy Commission	H. L. Volchok	GEOSECS—Fallout Radionuclides in Oceanic Water Columns.
Battelle Pacific Northwest Laboratories	D. E. Robertson	GEOSECS—Vertical Distribution of Trace Elements.
University of California, Scripps Institution of Oceanography	A. E. Bainbridge	GEOSECS—Operations Group.
University of California, Scripps Institution of Oceanography	H. Craig	GEOSECS—SIO Shipboard and Laboratory Measurements.
Columbia University, Lamont-Doherty Geological Observatory	W. S. Broecker R. G. Senechal	GEOSECS—Barium Determinations.
Columbia University, Lamont-Doherty Geological Observatory	W. S. Broecker, H. Feely, P. E. Biscaye, M. Bender	GEOSECS—Ra^{226}, Ra^{228}, Suspended Particulates, Mineralogy, and Barium Analyses.
University of Hawaii	P. Kroopnick	GEOSECS — Isotopic Measurements (C^{13}/C^{12}, O^{18}/O^{16}, H^2/H^1) of Dissolved Oxygen, Atmospheric Water Vapor, and Atmospheric CO_2.
Louisiana State University	L. H. Chan J. S. Haror	GEOSECS—Determination of Barium Concentration in Ocean Waters.
Massachusetts Institute of Technology	J. M. Edmond	GEOSECS—High-Precision Barium Measurements.
University of Miami	H. G. Ostlund	GEOSECS—Radiocarbon and Tritium Measurements.
Oregon State University	J. V. Byrne L. I. Gordon	GEOSECS—Nutrient Analysis and Measurements of Organic Carbon and Surface pH.
Queens College, The City University of New York	T. Takahashi	GEOSECS—Carbonate Chemistry of Sea Water.
University of Southern California	T. L. Ku	GEOSECS—Radium and Barium Analyses.
University of Washington	M. Stuiver	GEOSECS—C^{14} Ocean Water Analysis.
Woods Hole Oceanographic Institution	P. C. Mangelsdorf, Jr.	GEOSECS—Analysis of Major Ions in Sea Water by the Method of Difference Chromatography.
Woods Hole Oceanographic Institution	D. W. Spencer P. G. Brewer	GEOSECS—Trace Element and Particulate Matter Investigations.
Woods Hole Oceanographic Institution	D. W. Spencer J. M. Hunt	GEOSECS—Administration and Logistics.
Yale University	K. Turekian	GEOSECS—Strontium Analysis.

STUDIES OF BASELINE DATA, TRANSPORT, AND BIOLOGICAL EFFECTS OF POLLUTANTS IN THE OCEAN

The goals of these studies are: 1) To establish the concentration of selected important pollutants in biota, seawater, and sediments; (2) to understand the mechanisms and pathways by which pollutants move through the biota, seawater, and sediment and the rate of this movement; (3) to determine the effects of pollutants on marine organisms; and (4) to predict the final effect of ocean pollutants.

A baseline survey has been made that defines the problem of establishing the concentration of pollutants in the marine environment. Six investigators are measuring transport processes in both field and laboratory studies. The biological effects program is now being planned and will consist of field, laboratory, and microcosm experiments.

The projects now funded for pollutant transport studies are:

Organization	Investigator	Project Title
University of California, Berkeley	R. Risebrough	Formulation of Mass Balance Equations for Polychlorinated Biphenyls in Marine Ecosystems.[1]
University of California, Scripps Institution of Oceanography	E. Goldberg	The Fluxes of Synthetic Organics in the Marine Environment.[1]
University of California, Skidaway Institute of Oceanography	R. Lasker	Exchange Rates of Chlorinated Hydrocarbons and Similar Chemicals in Marine Food Chains.[1]
University of Georgia, Skidway Institute of Oceanography	H. Windom	The Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean.[1]
Harvard University	J. N. Butler	Transfer of Persistent Pollutants in Sargassum Communities.[1]
University of Rhode Island	R. A. Duce	Atmospheric Pollutant Transport and Deposition on the Sea Surface.[1]
Woods Hole Oceanographic Institution	G. R. Harvey	Uptake and Transfer of Chlorinated Hydrocarbons in the Atlantic Ocean.[2]

[1] 2-year projects. [2] 1-year project.

Scientists who participated in the completed baseline survey of the Atlantic, Gulf of Mexico and Caribbean Sea, and Pacific areas collected biological and geological data and water samples in oceanic areas contiguous to the United States. They used available reference samples to provide absolute calibration of analytical data. Interchange of replicate samples among participating lab-

oratories provided for intercalibration of analytical procedures. The interchange of data derived from reference and intercalibration analyses and from collected samples proved useful in evaluating analytical methodology and in maintaining research quality.

Atlantic Project

Investigators at the Woods Hole Oceanographic Institution (WHOI), Skidaway Institute of Oceanography, and a marine research team from the University of Rhode Island and University of Connecticut made a series of interrelated studies on the distribution pattern of selected chemical pollutants in the open Atlantic Ocean. Objectives of these studies were to identify or predict pollutants affecting the quality of the open ocean environment and to advise IDOE planning and coordinating activities of research priorities indicated by these identifications and predictions.

The WHOI portion of the project consisted of four phases: (1) To collect typical samples from the North and South Atlantic; (2) to establish analytical methods for measuring chlorinated and petroleum hydrocarbons in the samples; (3) to measure chlorinated and petroleum hydrocarbons in as many samples as possible, and (4) to convene a working group to evaluate all Atlantic data in the light of ecological, geochemical, and oceanographic knowledge, with the objective of making further recommendations to IDOE.

WHOI cruises, sampling programs, and tracklines are shown in figure 1. WHOI scientists collected an assortment of benthic organisms from moderate depths and an assortment of mesopelagic invertebrates and fishes from several depths between 100 and 1,000 m. Plankton and specific surface organisms were also collected over a wide geographical range.

The Skidaway Institute of Oceanography portion of the project was concerned with the analysis of heavy metals in organisms. Open ocean samples were obtained from the WHOI collections. To supplement and extend the regional coverage obtained by WHOI's RV *Gosnold,* inshore samples were obtained by the Skidaway Institute RV *Golden Isles.*

The Skidaway Institute measured metal concentrations (As, Cd, Cu, Hg, Pb, Zn) in organisms from several trophic levels within the marine food web. The samples, including plankton, were obtained along the Georgia coast by WHOI's RV *Knorr.* Additional plankton samples were provided by WHOI from samples taken previously by WHOI's RV *Atlantis II* off the northeast coast of the United States and the northwest coast of Africa. Other samples were collected by Duke University Marine Laboratory's RV *Eastward* between Beaufort, N.C., and Jacksonville, Fla. In addition to collections of zooplankton, collections of benthic and pelagic organisms of higher trophic levels were made between Georgia and the Sargasso Sea during several cruises of WHOI's RV *Gosnold.* Water samples were also collected off the Georgia coast and analyzed for Cd, Cu, Hg, and Zn. Figures 2 to 9 show the sampling locations

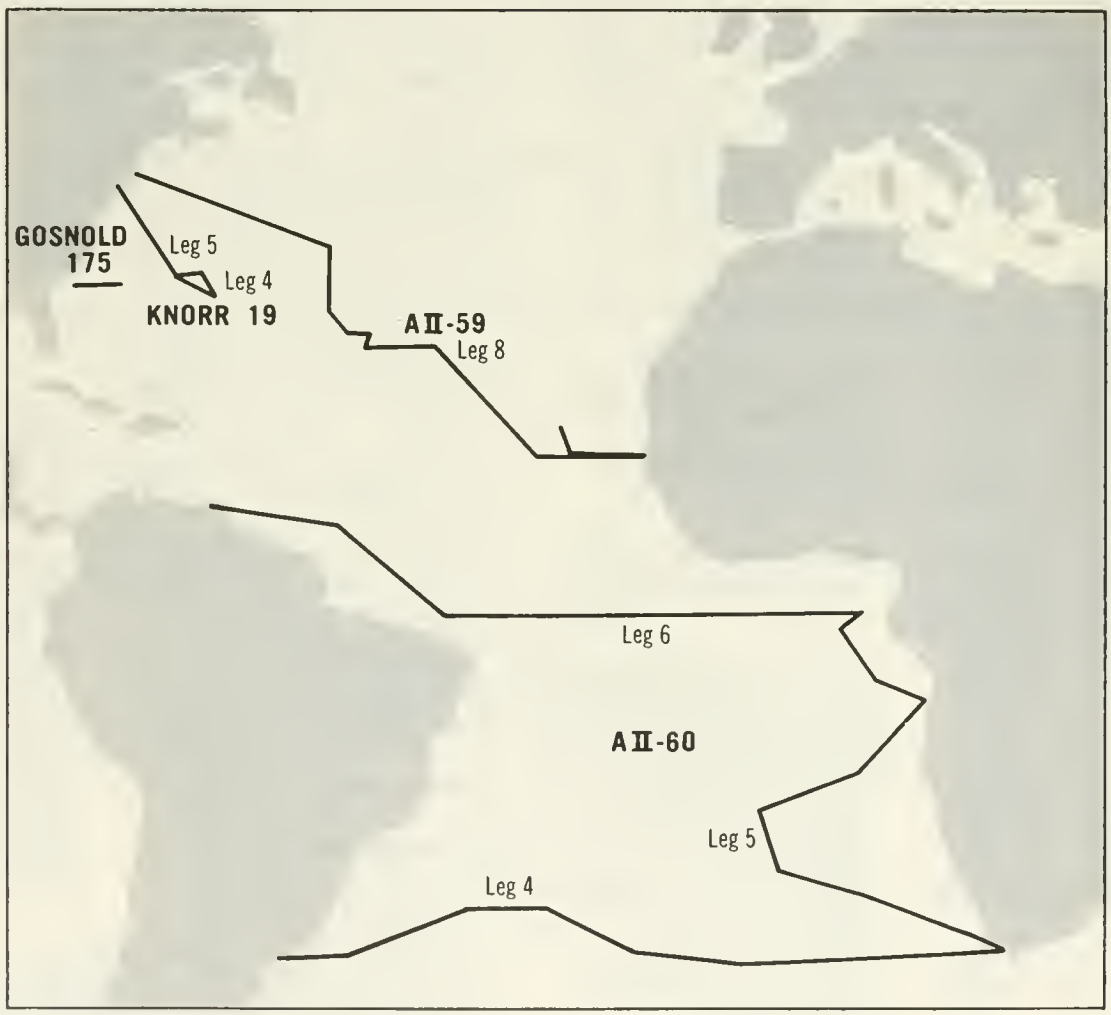


FIGURE 1.—Atlantic environmental quality baseline-data-acquisition cruises.

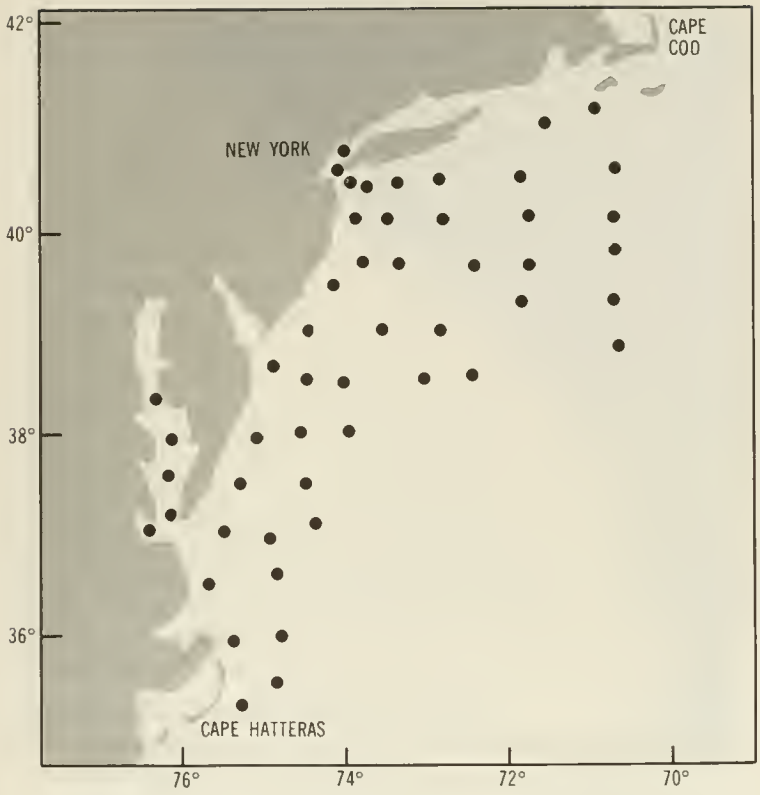


FIGURE 2.—Plankton sampling stations RV *Atlantis II* Cruise 52.

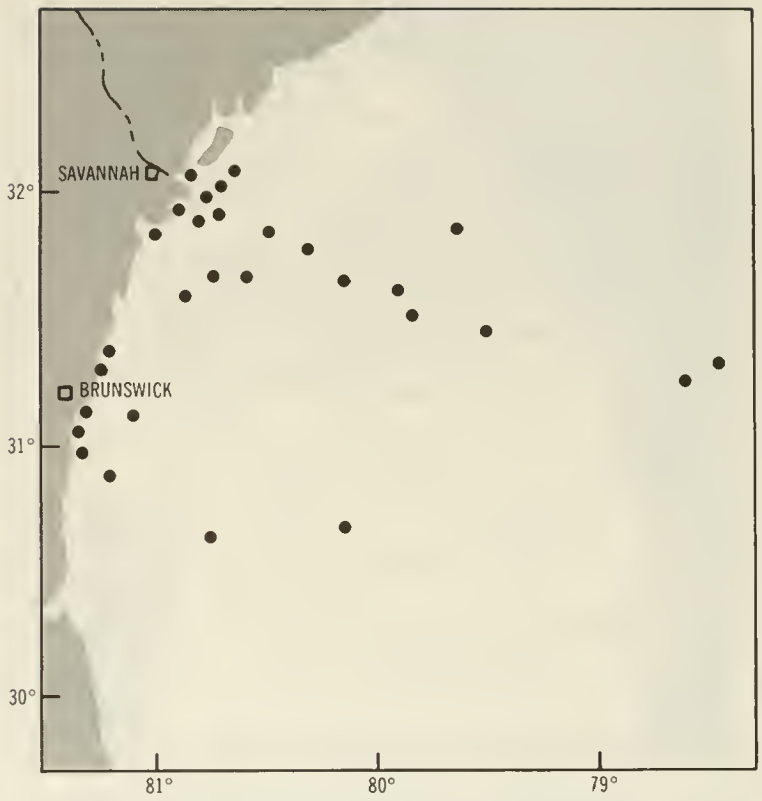


FIGURE 4.—Plankton sampling stations RV *Gosnold* Cruise 175.

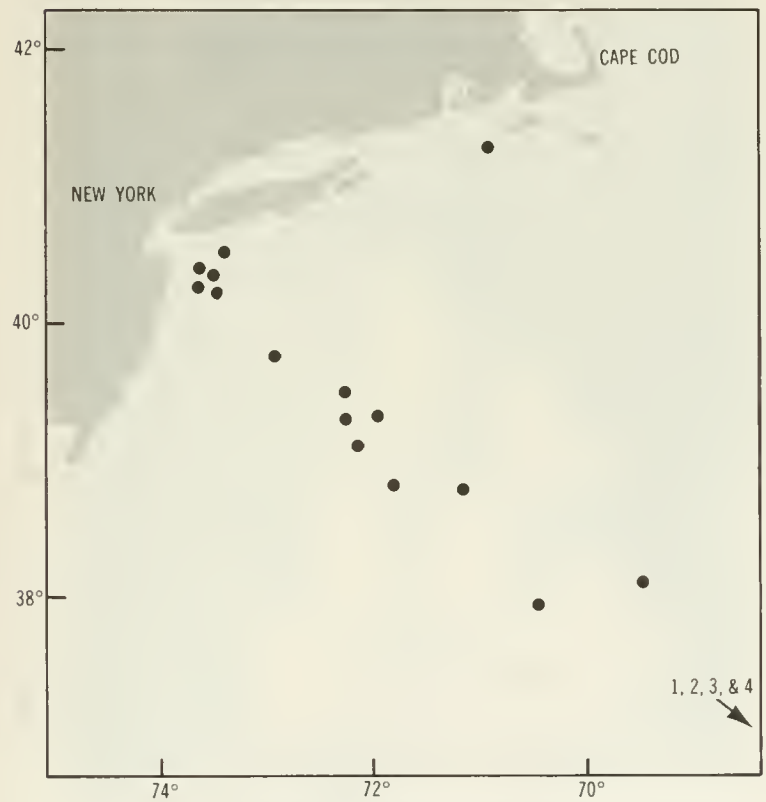


FIGURE 3.—Plankton—sampling stations RV *Knorr* Cruise 19-5.

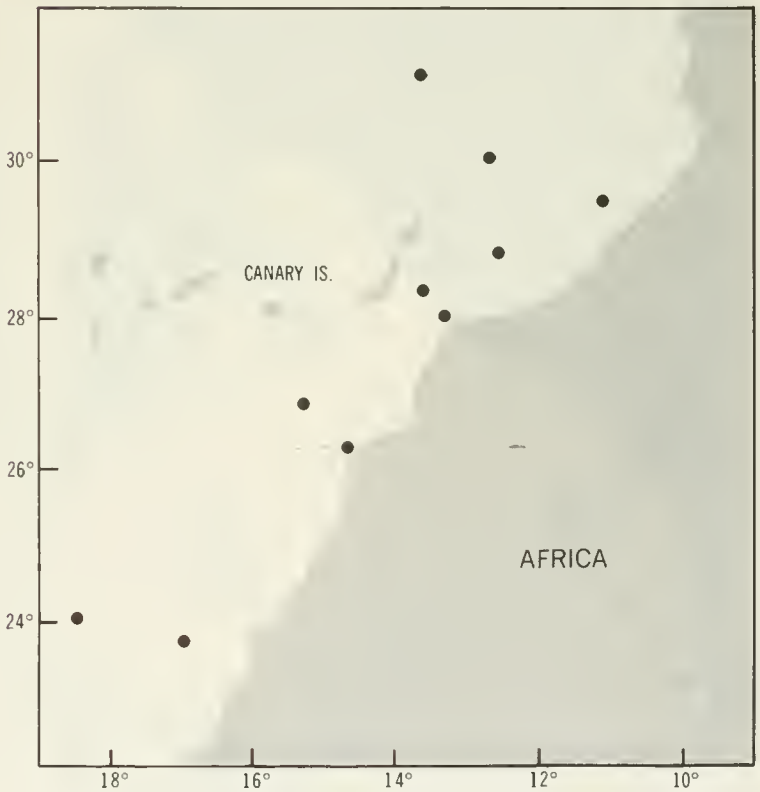


FIGURE 5.—Plankton sampling stations RV *Atlantis II* Cruise 59.

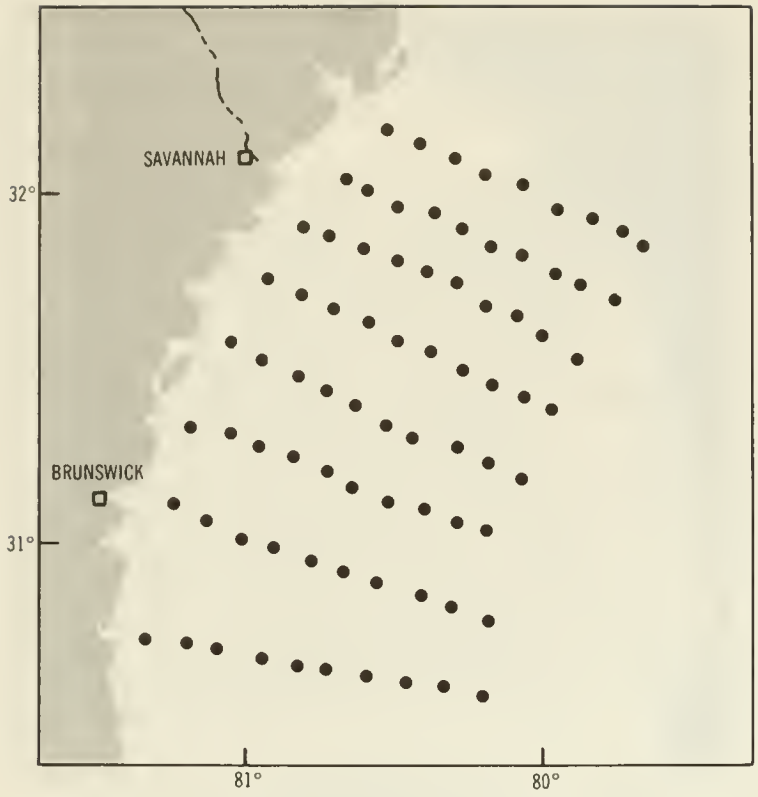


FIGURE 6.—Location of water sampling stations off Georgia coast.

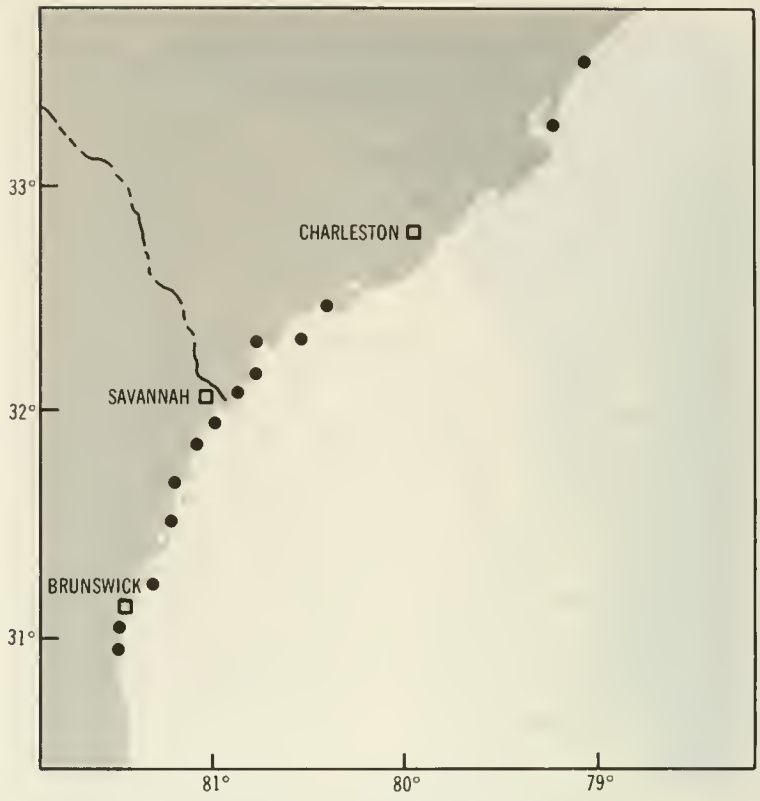


FIGURE 8.—Mollusk sampling stations.

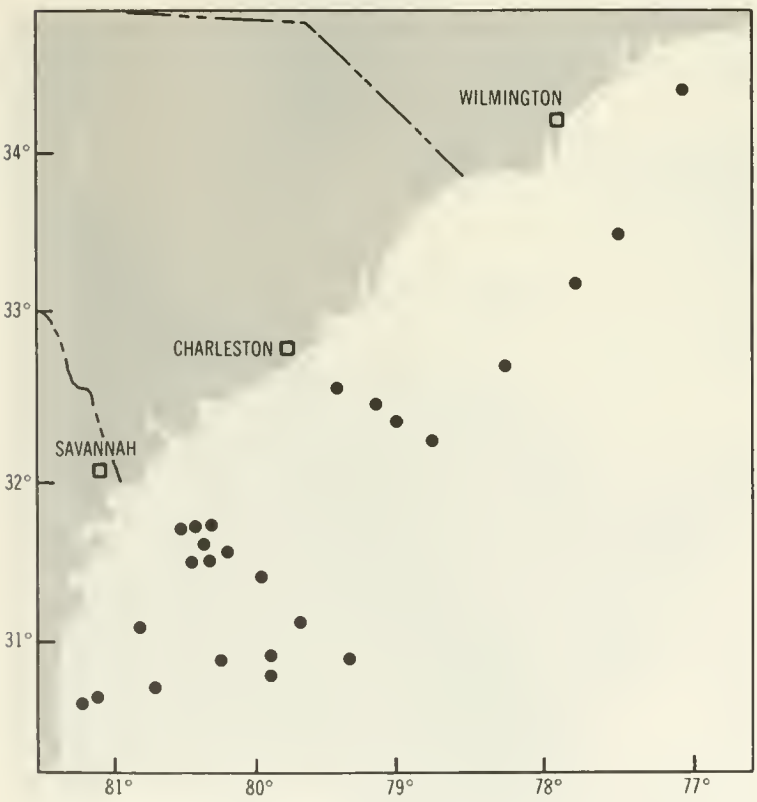


FIGURE 7.—Plankton sampling stations, RV *Eastward*, August 1971.

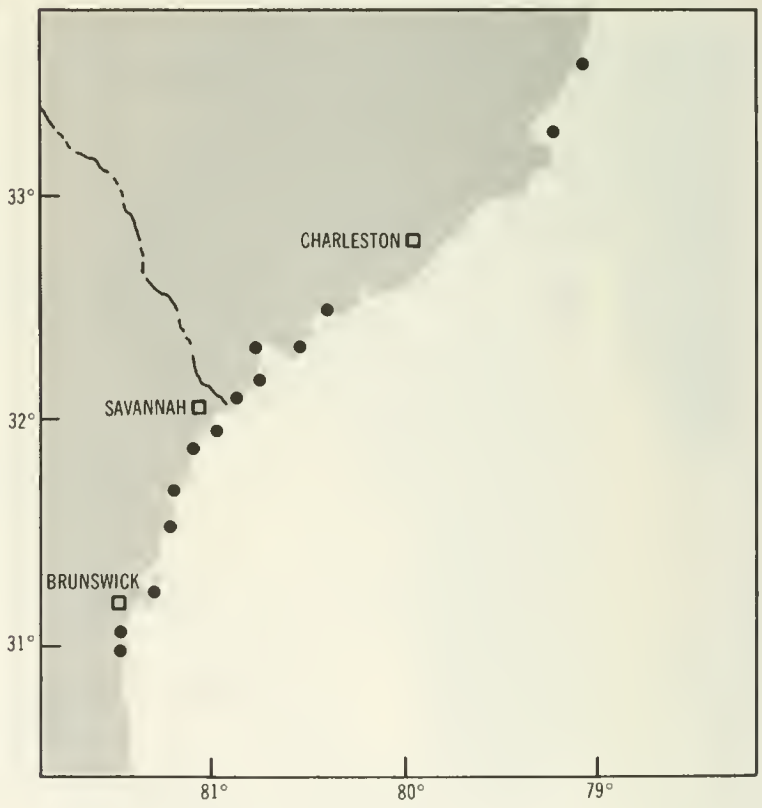


FIGURE 9.—Mollusk and crustacean samples.

for water and biological specimens analyzed for metals by the Skidaway Institute. Measurements for As, Cd, Cu, Pb, and Zn were obtained from Chondrichthyes, crustaceans (crabs, shrimp, spiny lobsters), fish-eating ducks, mollusks (bivalves, snails, squid), mixed phytoplankton, one specimen of porpoise (*Tursiops truncatus*), *Sargassum*, *Spartina*, teleosts, and zooplankton.

The University of Rhode Island and University of Connecticut portion of the program was concerned with the analysis and assessment of pollutants transported by the atmosphere, specifically the atmospheric particulates that interact with sea-surface materials. Baseline data were obtained for metals in air particulates, organisms, and sea-surface films; for lipids, as pollution indicators, in atmospheric particulates and sea-surface films; and for pesticide residues and polychlorinated biphenyls in atmospheric particulates, organisms, sea-surface films, and sediments. Figures 10 to 14 show the sampling locations for chlorinated hydrocarbons and lipids in the marine atmosphere and sea-surface microlayer, heavy metals associated with Northwest Atlantic zooplankton, and trace metals. Sea-surface microlayer samples were collected from coastal, estuarine, and oceanic areas in the Atlantic. Atmospheric particulate samples for trace metals were collected over wide areas of the North Atlantic from a specially constructed bow tower on the University of Rhode Island's RV *Trident*.

Gulf of Mexico and Caribbean Project

Investigators at Texas A&M University, the University of Texas, and the Puerto Rico Nuclear Center made interrelated studies of

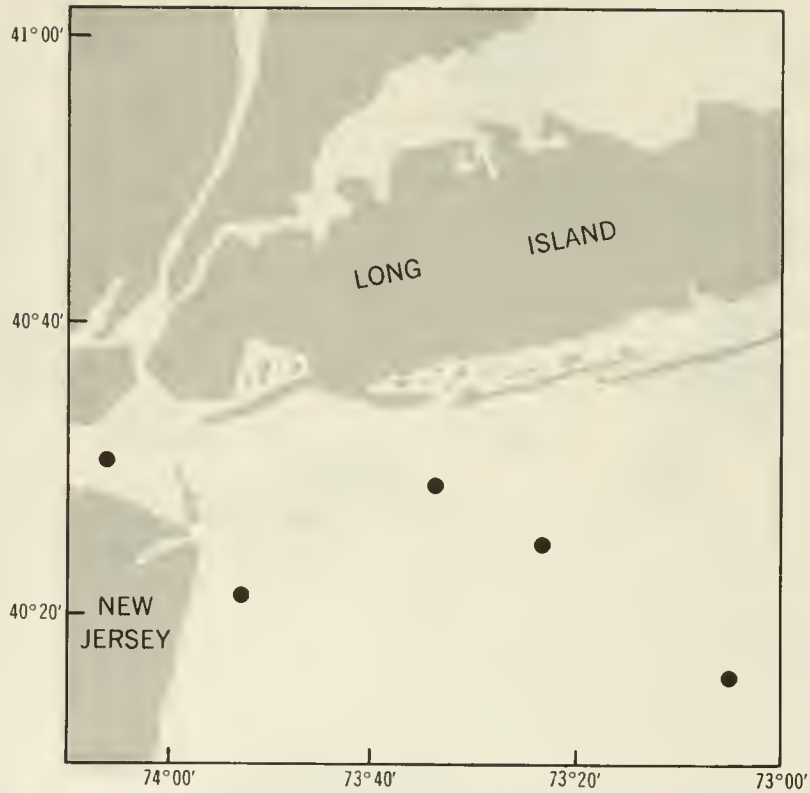


FIGURE 11.—Sea-surface microlayer sample locations in New York Bight (RV *Gosnold*, Cruise 176). Samples were analyzed at the University of Rhode Island for trace metals, lipids, and chlorinated hydrocarbons.

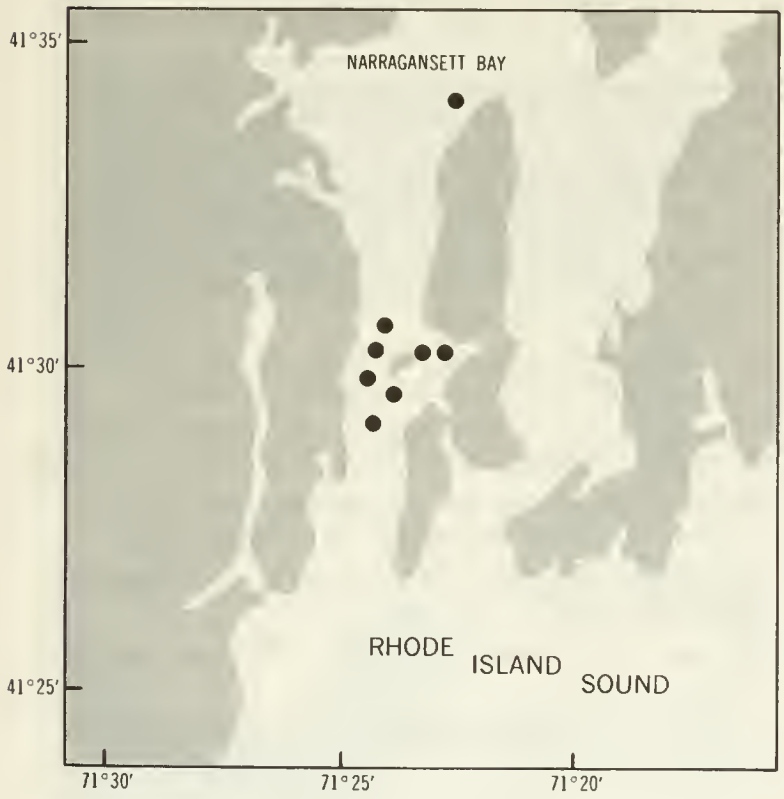


FIGURE 10.—Sea-surface microlayer sample locations in Narragansett Bay, R.I. Samples were analyzed at the University of Rhode Island for trace metals, lipids, and chlorinated hydrocarbons.

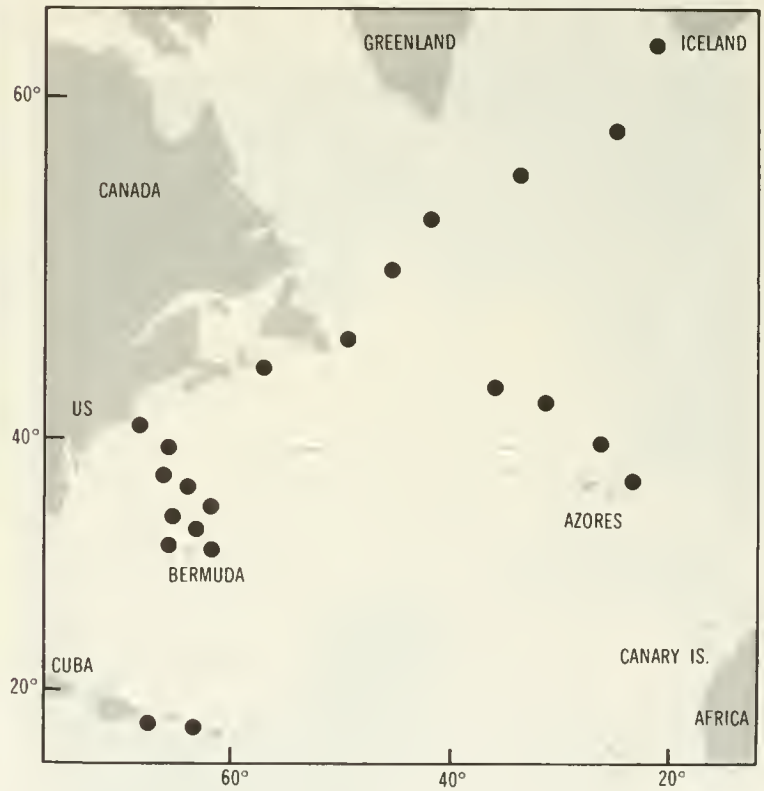


FIGURE 12.—Sample locations for atmospheric particulate collections in the North Atlantic Ocean. Samples were analyzed at the University of Rhode Island for trace metals.

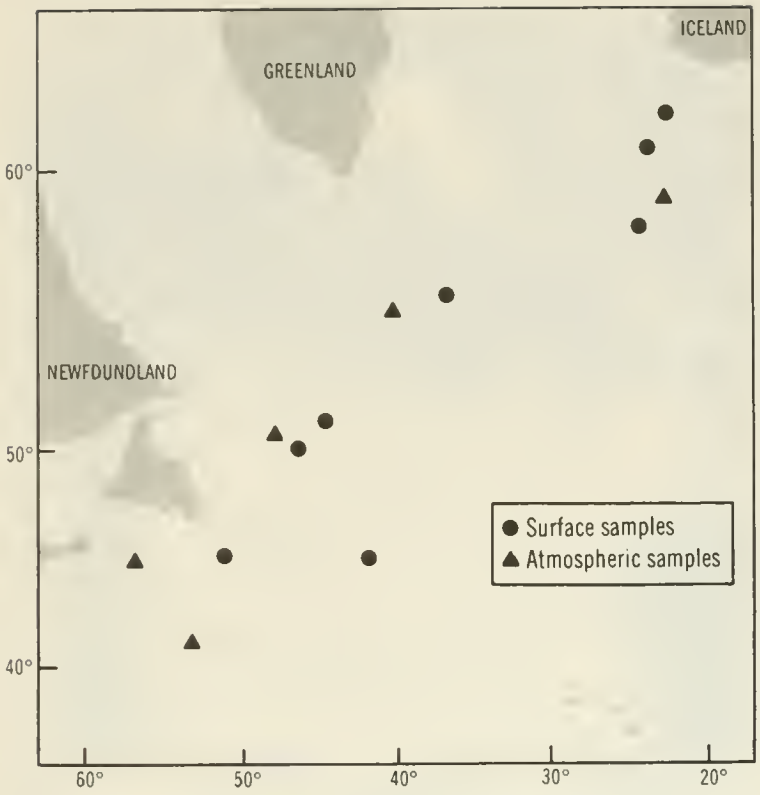


FIGURE 13.—Sea surface microlayer samples and atmospheric particulate collections RV *Trident* Cruise 102. Samples were analyzed for trace metals, chlorinated hydrocarbons, and lipids.

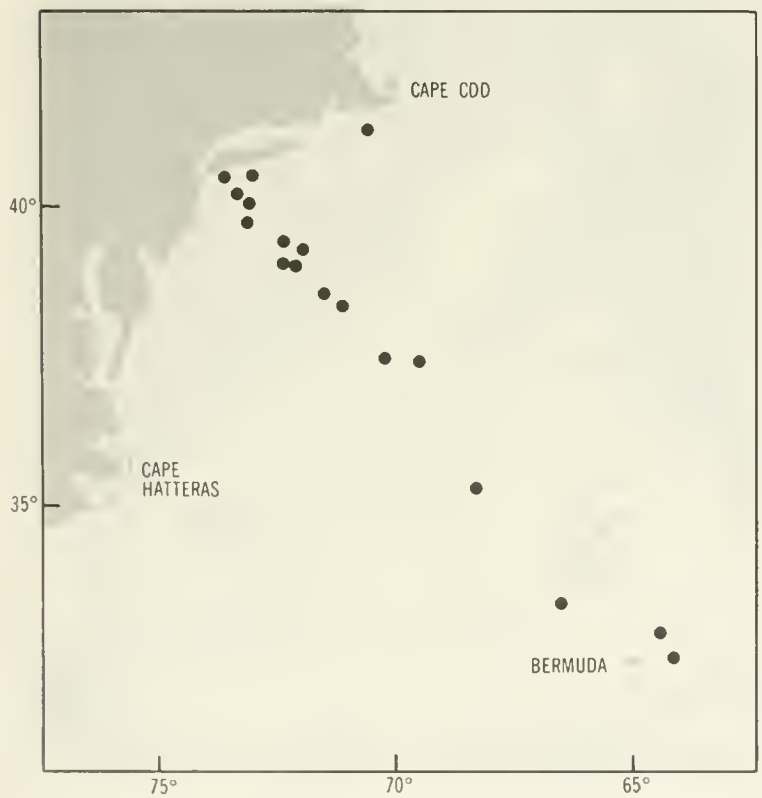


FIGURE 14.—Zooplankton collections RV *Knorr*, Cruise 19, leg 5. Concentrations of Cu, Hg and Pb in zooplankton measured by Marine Sciences Institute, University of Connecticut.

the distribution patterns and concentrations of heavy metals, chlorinated and petroleum-derived hydrocarbons, and trace elements in marine organisms of several trophic levels, in sediments and in water samples.

The Gulf and Caribbean sampling program was carried out by the Texas A&M RV *Alaminos* and Puerto Rico Nuclear Center RV *Palumbo* (fig. 15). Types of baseline data collected were: Dissolved light hydrocarbon concentrations in the surface water of the Gulf and western Caribbean; trace elements (Co, Cs, Fe, Hg, Sb, Sc, U, Zn) in benthos, nekton, plankton, *Sargassum*, sediments, and water samples of the western Caribbean; Hg in Gulf waters; petroleum-derived organic matter in phytoplankton, *Sargassum*, teleost, water samples; zooplankton; chlorinated hydrocarbons (DDT's and PCB's) in Chondrichthyes, plankton, shrimp, and squid; teleosts; and heavy metals in muscle tissues of a few assorted invertebrates, some plankton samples, and teleosts.

Figure 16 shows plankton sampling locations; fig. 17, fish sampling locations; fig. 18, locations for which Hg was measured in water samples; fig. 19, locations for which Hg was measured in sediments; fig. 20, Mississippi delta locations for which total Hg was measured; and fig. 21, locations of zooplankton samples for which the percentage compositions of hydrocarbons were measured.

Pacific Project

The Pacific baseline data-acquisition program is a cooperative project involving the University of Alaska, Battelle Memorial Institute, California Institute of Technology, NOAA's National Marine Fisheries Service, Oregon State University, Scripps Institution of Oceanography, Stanford University, and University of Washington.

The Scripps Institution of Oceanography RV *Thomas Washington*, on several legs of the Aries Expedition (February 27 to April 30 and September 3 to October 3, 1971), made about 50 collections for chemical analysis. These collections were made only in pelagic areas within the surface layers, at middepths, and at abyssal depths, and consisted of several species of fish, neuston, squid, and zooplankton.

Aries Expedition and other cruise samples were sent to cooperating institutions and laboratories for chemical analyses as follows:

Institute of Marine Science, University of Alaska: Cd, Hg, and Pb in Pacific fishes, benthic and pelagic invertebrates, phytoplankton, salmon, and zooplankton.

Battelle Northwest Laboratories: Ag, As, Cd, Cu, Cs, Hg, Ni, Sb, Se, V, and Zn in biological and sediment samples.

California Institute of Technology: Cd, Pb, and Sn in fishes, invertebrates, plankton, and sediment water samples.

Hopkins Marine Station, Stanford University: DDT (and metabolites), Cd, Cr, Cu, Pb, and Zn in biological samples.

Oregon State University: Cd, Cu, Hg, and Zn in biological and sediment samples.

University of Washington: As and Hg in biological, sediment, and water samples.

In addition to the Aries Expedition samples, other sampling programs for the Pacific Project are cited in the Appendix.

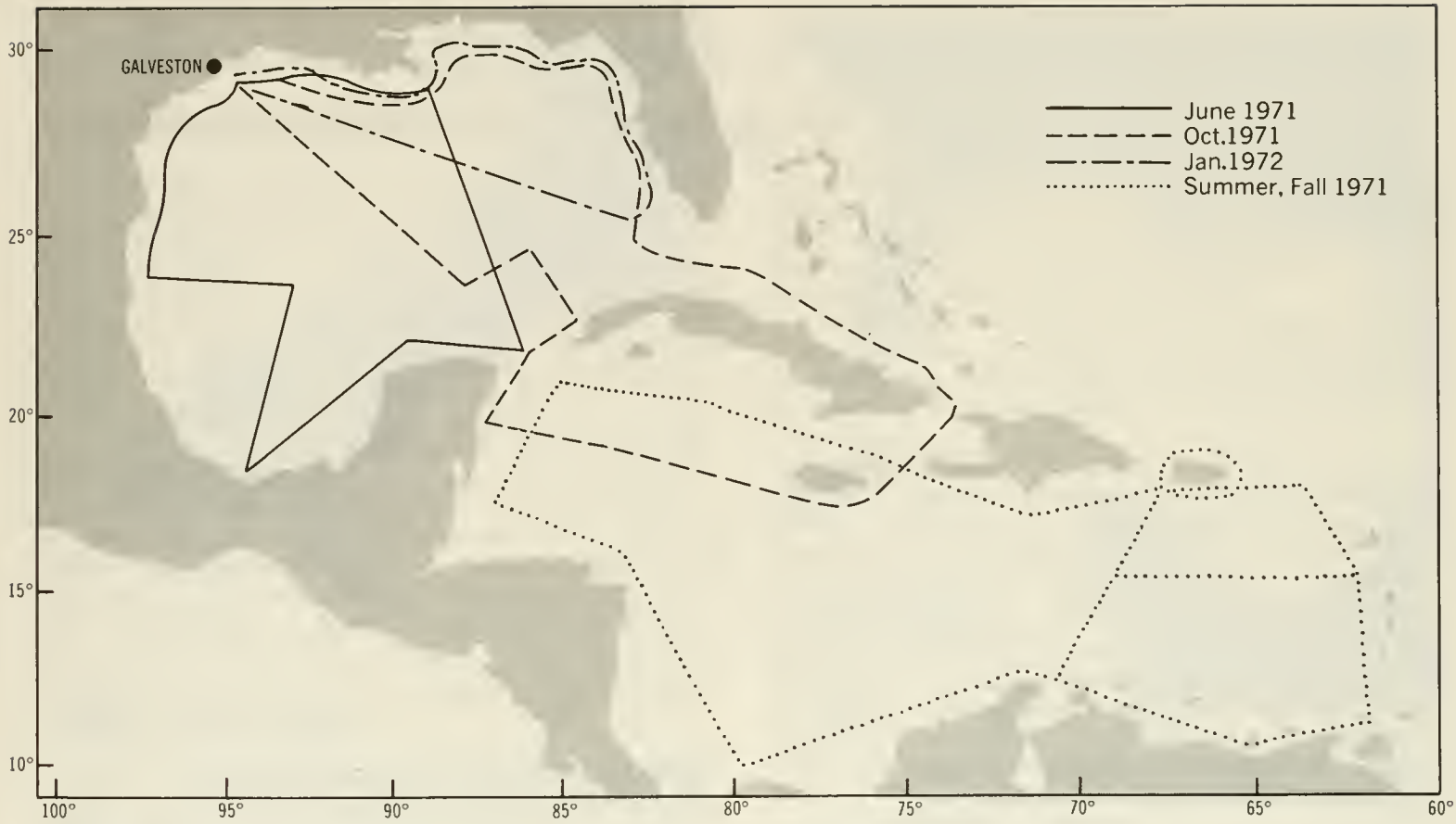


FIGURE 15.—Gulf of Mexico and Caribbean Sea environmental quality baseline-data-acquisition cruises.

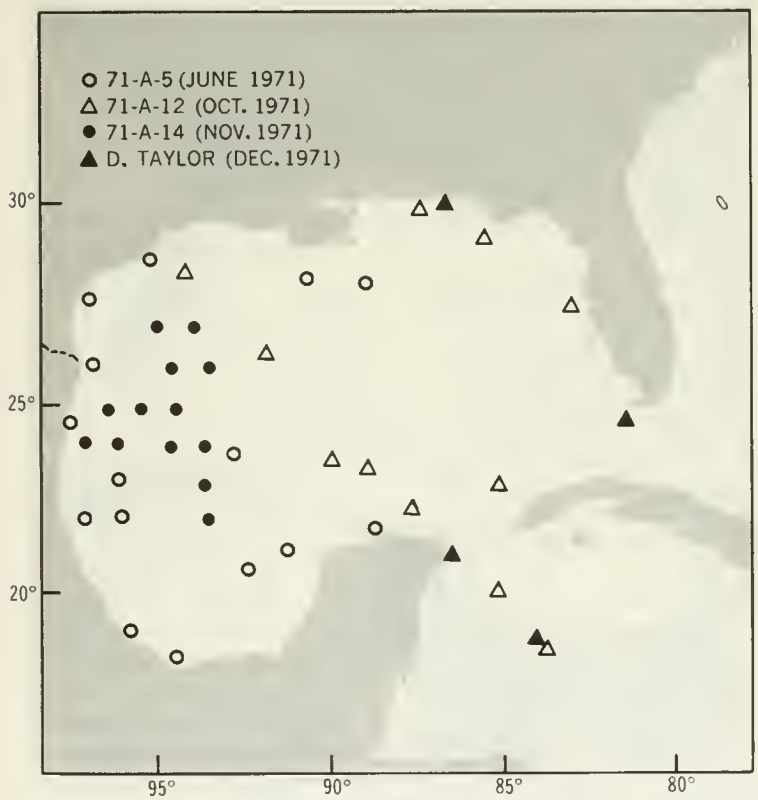


FIGURE 16.—Plankton sampling locations in Gulf of Mexico and Caribbean Sea.

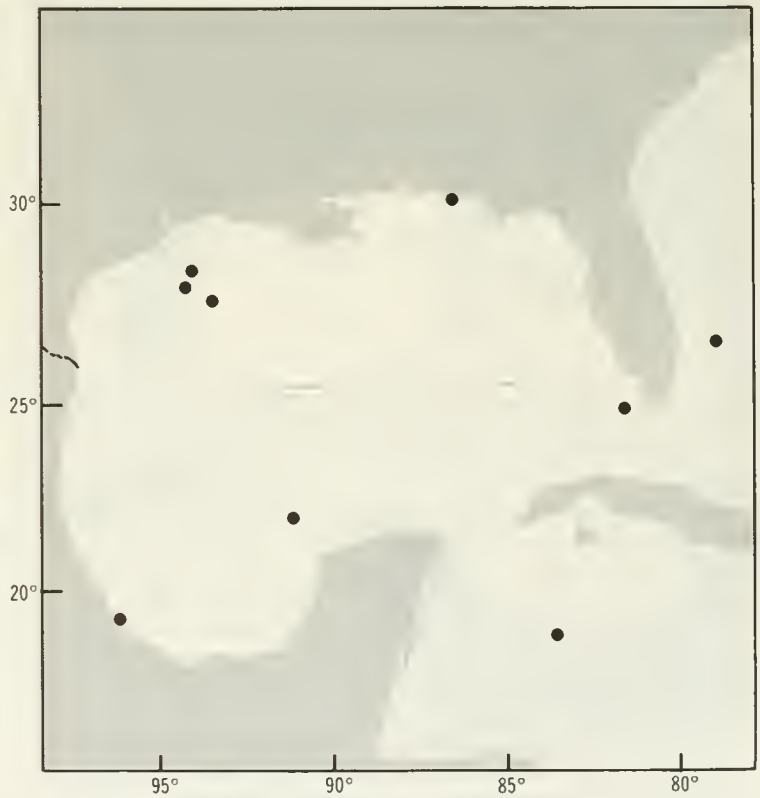


FIGURE 17.—Fish sampling locations in Gulf of Mexico and Caribbean Sea.

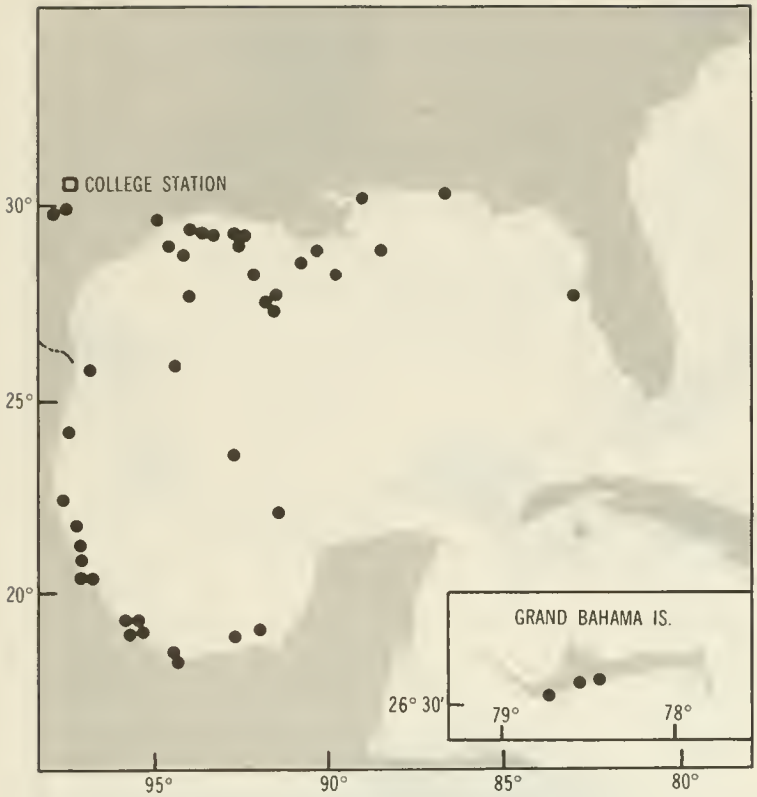


FIGURE 18.—Stations for total Hg in water samples in Gulf of Mexico and off Grand Bahama Island.

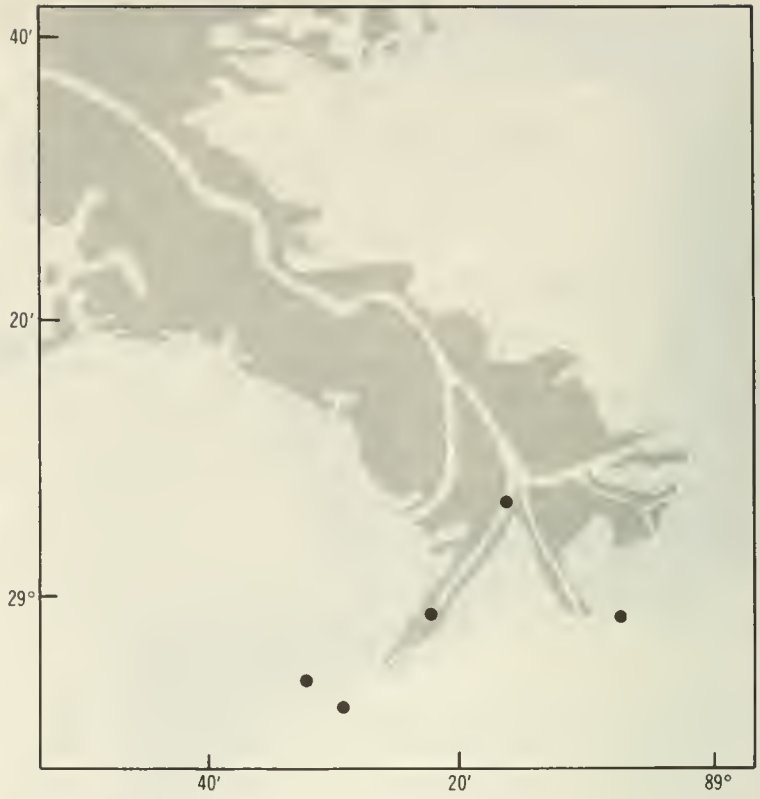


FIGURE 20.—Stations for total Hg in water samples taken in and around the Mississippi Delta.

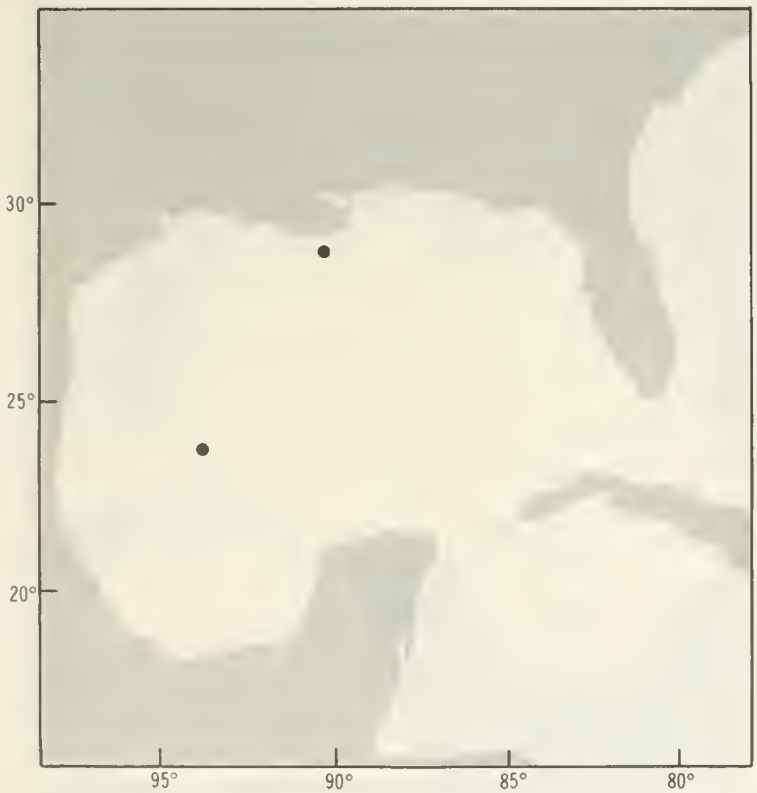


FIGURE 19.—Stations for measuring Hg in seliment samples, Gulf of Mexico.

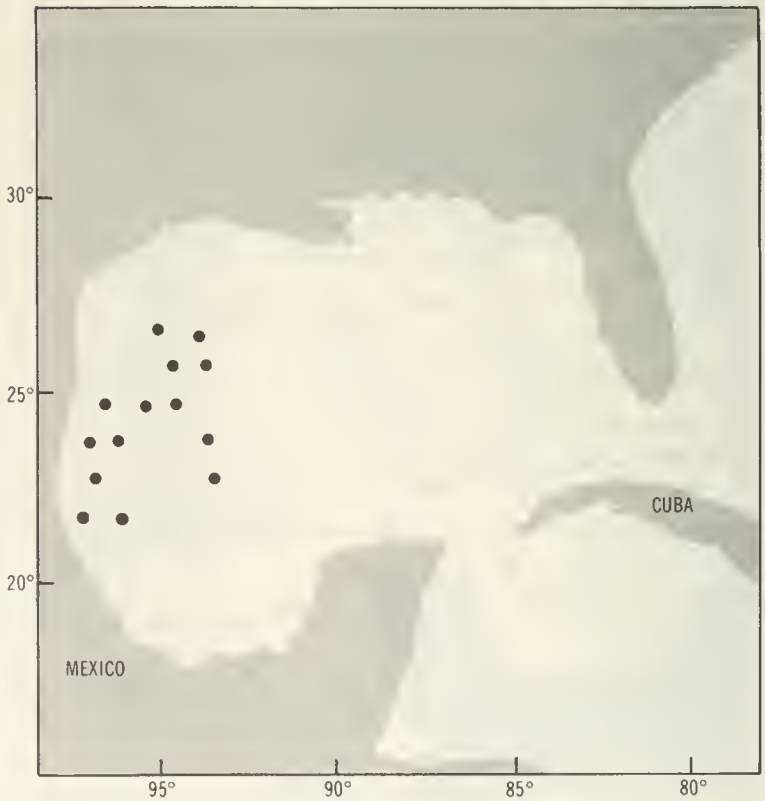


FIGURE 21.—Locations of zooplankton samples for which the percentage composition of hydrocarbons was measured.

Environmental Forecasting Program

The purpose of the IDOE Environmental Forecasting Program is to provide the scientific base to improve environmental forecasting, which requires a repetition of observations, development of realistic (predictive) models, and understanding of physical principles. The IDOE Program will concentrate on large-scale, long-period phenomena, which can not be easily investigated by single universities or investigators. The projects include: "Climate: Long-range Investigation, Mapping, and Prediction" (CLIMAP), a study of ocean circulation during previous climatological regimes that was formerly called the "Paleo-Oceanography Study"; the "Mid-Ocean Dynamics Experiment" (MODE), a study of the contributions of meso-scale eddies to the ocean's circulation; and the "North Pacific Experiment" (NORPAX), a study of long-period, large-scale, ocean and atmosphere interactions. In addition, Geochemical Ocean Sections (GEOSECS), a study of deep-ocean diffusion and circulation under the IDOE Environmental Quality Program, and the physical portions of the "Coastal Upwelling Experiment" (CUE), which in 1972 became part of the Coastal Upwelling Ecosystem Analysis (CUEA) project under the IDOE Living Resources Program, make important contributions to the Environmental Forecasting Program.

These studies will increase our understanding of ocean-atmosphere interactions and provide a better base for improved extended forecasts of weather over the Eastern North Pacific and North America. Better forecasts will improve planning for construction, farming, marine, and transportation activities. These studies also should produce better estimates of pollutant dispersal; improve fishery prediction; increase the accuracy in forecasting advantageous shipping routes; provide for greater utilization of the oceans as a source of food or a heat sink for man's activities; and enhance our ability to calculate water renewal rates in the deep ocean—with application to disposal of contaminants, dispersal of nutrients, and development of predictive models of global circulation.

CLIMATE: LONG-RANGE INVESTIGATION, MAPPING, AND PREDICTION (CLIMAP)

To understand the mechanism of climatic change, the pattern of change through time must be examined in detail. That is the purpose of the CLIMAP study.

Of the natural fluctuations in the global environment, few are more significant to human ecology that climatic change. The impact of climatic fluctuations is supported by historical records from medieval Iceland and Europe, where during the 13th and 14th centuries deteriorating climatic conditions were marked by great extensions of North Atlantic sea ice, a completely frozen Baltic, crop failures in southern Europe, and extinction of the people in the Greenland colonies.

Surface oceanic current systems have an important effect on local climate; their changes through time can be more accurately documented by a study of the deep-sea sediments. The Gulf Stream provides an excellent example. It is known that the position of the Stream changes through time; sometimes the Stream is displaced to the north, sometimes to the south. However, it is not known if these fluctuations are in harmony with the major global cycles or if they have a different frequency.

CLIMAP project scientists will examine changes in current patterns and water mass properties in the Atlantic and Pacific Oceans during the Quaternary. For the ocean areas of investigation, many sediment cores are already available. From these cores, surface oceanic climatic fluctuations associated with glacial and interglacial transitions will be determined. For this purpose, four oceanographic maps will be constructed to show conditions:

1. 6,000 years ago—the postglacial thermal maximum; 2. 17,000 years ago—the last glacial stage; 3. 120,000 years ago—the last interglacial period; and 4. 700,000 years ago—the mid-Pleistocene. Comparable maps for the present time will form the basis for interpretation.

The general research plan consists of: (1) A routine paleontological examination of existing cores to determine which are most suitable for the base grid for the paleo-oceanographic study; (2) an acquisition and initial interpretation of geochemical, paleontological, and sedimentological data on suitable grids for all levels; (3) a multivariate analysis and computer model application to provide interpretive paleo-oceanographic maps for each level (following extension and consolidation of present work on quantitative relationships between the oceanic environment and sediment properties); and (4) an interpretation of study results in close coordination with ongoing examination of Greenland and Antarctic ice cores, which yield critical information about high-latitude glacial and interglacial climates and their effects on the temperature and salinity of bottom and surface ocean waters.

A chart depicting the sea-surface temperature for the North Atlantic 17,000 years ago is being completed, and a corresponding chart for the South Atlantic is scheduled to be completed later.

The CLIMAP study contains the following projects:

Organization	Investigator	Project
Brown University Columbia University Oregon State University	J. Imbrie J. D. Hays T. C. Moore, Jr.	Paleo-Oceanographic Studies of Late Quaternary Ocean Circulation Climate in the North Atlantic and Pacific Oceans.
University of Miami	C. Emiliani	High Resolution Study of Environmental Changes, During the Late Pleistocene Period and Recent Times.

MID-OCEAN DYNAMICS EXPERIMENT (MODE)

The purpose of MODE is to establish the dynamics and statistics of mesoscale motions, their energy sources, and their role in the general circulation. It is estimated that mesoscale eddies, if they are everywhere present, would contain at least as much kinetic energy as the main ocean circulation and possibly 10 times more. The origin, quantity, behavior, and estimation of eddie kinetic energy are being studied by those who are devising numerical models. It is known that such eddies exist in the atmosphere and that their kinetic energy content is comparable to that of the mean atmospheric flow and must be properly taken into account for successful numerical simulation. Such knowledge may be even more important in modeling oceans. MODE consists of a continuing theoretical effort as well as three field experiments—MODE-0, MODE-I, and (possibly) MODE-II. The site chosen for the first two field experiments is a small area 400 km. in diameter and 5 km. deep near the Tropic of Cancer, south of Bermuda.

Early in the planning for MODE, it was evident that additional information was required on mesoscale eddies, so a first observational effort—MODE-O—was initiated. MODE-O took place from November 1971 to March 1972.

MODE-I is scheduled for March-July 1973. Five or six ships are expected to take part. Eighty current meters will be suspended from 25 moorings arranged in a circular pattern with the meters concentrated at 500-, 800-, 1,500-, and 3,000-db levels plus a deep level located either 100 m above bottom on the abyssal plain or 4,000 m above rough abyssal hill terrain. Complementary observations will include tracking SOFAR (sound fixing and ranging) and Swallow floats, bottom pressure measurements, vertical profile (salinity-temperature-depth, current velocity) measurements, and transport measurements, and transport measurements from aircraft.

MODE-II will depend on MODE-I results, the results of the U.S.S.R. large buoy array experiment, and international conferences. Constraints include the need for a 1- or 2-year time series, an extensive array, and international cooperation. MODE-II is tentatively scheduled for 1976 and 1977.

Projects for the MODE studies are:

Organization	Investigator	Project Title
Institute of Geophysics and Planetary Physics, University of California, San Diego	W. H. Munk F. E. Snodgrass W. S. Brown J. D. Irish	Fluctuations in the Abyssal Pressure and Temperature Field.
University of California, Scripps Institution of Oceanography	C. S. Cox R. L. Parker	Preparation for Sargasso Sea Studies of Electric Field.
University of California, Scripps Institution of Oceanography	C. S. Cox R. L. Parker V. Vacquier J. H. Filloux	Electromagnetic Studies of the Ocean Lithosphere and of the Ocean Water Currents at the MODE-I Site.
University of California, Scripps Institution of Oceanography	R. E. Davis M. C. Hendershott W. H. Munk	Design of the MODE Array as an Inverse Problem.
University of California, Scripps Institution of Oceanography	M. C. Hendershott	Numerical Evaluation of Suggested MODE Sites.
University of Cambridge, United Kingdom	P. Rhines	The Theoretical and Practical Study of a Turbulent, Quasi-geostrophic Ocean Interior.
Columbia University	T. E. Pochapsky	Deep Ocean Current Fine Structure.
Harvard University	D. J. Baker, Jr.	Deep-Sea Pressure Measurements.
Harvard University	A. R. Robinson	Theoretical Studies and Numerical Models.
Johns Hopkins University	F. P. Bretherton	An Exploratory Study ot Synoptic Maps for MODE.
Massachusetts Institute of Technology	C. Wunsch	Temperature Arrays for MODE.
Massachusetts Institute of Technology	H. M. Stommel	Administration of MODE.
National Institute of Oceanography, United Kingdom	J. Swallow J. Crease	Swallow Float and Current Meter Arrays.
Atlantic Oceanographic and Meteorological Laboratories, NOAA, and the National Institute of Oceanography, United Kingdom	D. Hansen J. Crease	MODE Density Program.
Nova University	W. S. Richardson	Oceanic Current Measurements From Aircraft as Part of the MODE Experiment.
University of Rhode Island	W. Sturges J. A. Knauss	Current Meter Arrays for MODE.
Woods Hole Oceanographic Institution	N. P. Fofonoff W. J. Schmitz, Jr. F. Webster	Moored Array Studies.
Woods Hole Oceanographic Institution	K. F. Hasselmann	Investigation of Interactions Between Short Internal Gravity Waves and Larger Scale Motions in the Ocean.
Woods Hole Oceanographic Institution	E. Katz R. Nowak	MODE: Observations of an Isopropyl Surface.
Woods Hole Oceanographic Institution	A. D. Voorhis D. C. Webb	SOFAR Float Experiment.
Woods Hole Oceanographic Institution	R. G. Walden H. O. Berteaus	SOFAR Float Listening Station.
Woods Hole Oceanographic Institution	D. C. Webb	Vertical Profiles of Horizontal Currents.
Woods Hole Oceanographic Institution	P. Welander	A Theoretical-Numerical Study of Geostrophic Eddy Motions in the Ocean.
Yale University	H. T. Rossby	Flat and Inverted Echo Sounder Experiments for MODE.

Figure 22 shows the location of the MODE-1 Field project As of May 1972, no field work other than gear trials has been conducted. Serial stations and STD measurements were obtained by the RV *Trident* on Cruise 105 in November 1971 and Cruise 107 in December 1971. Current-meter arrays were set out near 30°N., 70°W., by the RV *Trident* on Cruise 104 during October and November 1971 and retrieved on Cruise 109.

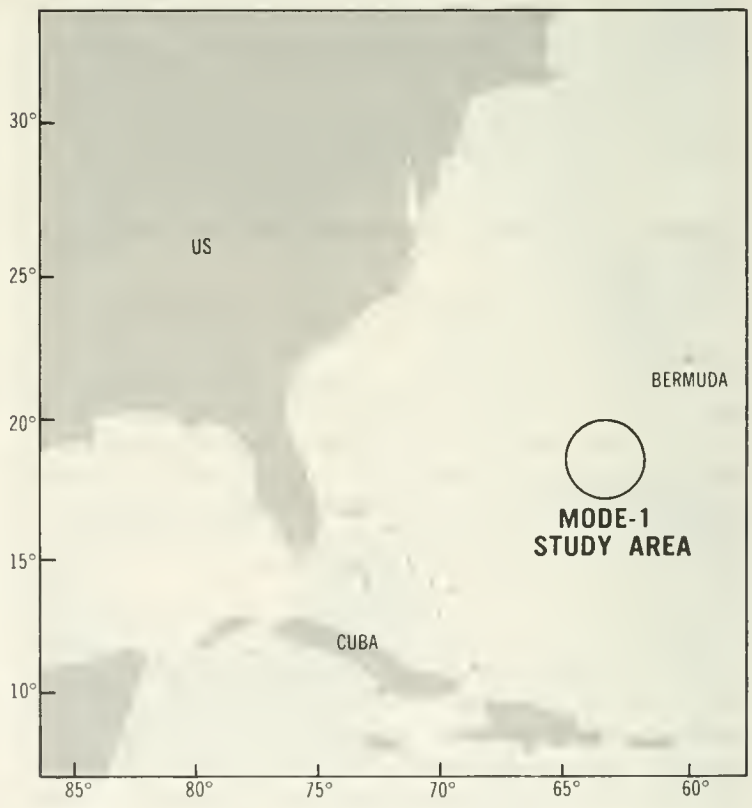


FIGURE 22.—Location of MODE-1 Field Experiment.

NORTH PACIFIC EXPERIMENT (NORPAX)

For the past 5 years, the Office of Naval Research (ONR) has been supporting research in the North Pacific to identify oceanic processes relating to anomalous weather conditions. Large areas of abnormally hot or cold sea-surface temperatures (anomalies related to 30-year, monthly-mean values) were identified in the North Pacific; it was postulated that these surface temperature anomalies, via ocean-atmosphere interaction, affect the climate from the Pacific eastward across the entire North American continent.

It became obvious that the ongoing research effort was insufficient to discover the causes of the environmental phenomena so far identified. Therefore, IDOE and ONR combined resources under an interagency agreement for joint, long-term funding to produce a larger and more comprehensive effort, the North Pacific Experiment (NORPAX), than either could support alone.

As now formulated, NORPAX consists of a scientific effort (including a visiting scientist program) and five supporting technical programs to: (1) Gather data from island stations, (2) gather data from fixed buoys, (3) gather data from drifting buoys, (4) provide ship support, and (5) archive data for subsequent retrieval from a master data library.

NORPAX is planned to be carried out in four major operational phases over the next 9 years. Phase-I will take 1½ years and will involve development of theory and numerical models, test and deployment of a data management system, and establishment of a versatile scientific support program. Phase-II will last 1 year and will principally involve use of the results from the data gathering and scientific support systems. Based on the results and knowledge gained during Phases I and II, the data gathering network will be widened during Phase III, which will require about 1 to 1½ years, depending on the amount of expansion needed. Phase IV, lasting 5 years, will involve operation of the data gatherings systems and analysis of the incoming data.

Still in its formative stage, NORPAX includes scientists from the University of California in Los Angeles, University of California in San Diego, and University of Hawaii. The principal investigator for the project is W. Nierenberg of the Scripps Institution of Oceanography.

Organization	Investigator	Project Title
University of California at Los Angeles	J. Bjerknes	Atmospheric Teleconnections.
University of California in San Diego	T. Barnett	Drifting Buoys.
University of California in San Diego	J. Huang	Numerical Modeling.
University of California in San Diego	J. Namias	Large-scale Ocean-atmosphere Coupling in the Midlatitudes of the North Pacific Ocean.
University of California in San Diego	W. Nierenberg	Scientific and Operational Support.
University of California in San Diego	B. Tatt	Equatorial Ocean Circulation.
University of California in San Diego	W. White	Subarctic Front.
University of Hawaii	K. Wyrtki	Circulation in the California Current.

NOAA PROJECTS

Four projects that were initiated by the National Oceanic and Atmospheric Administration (NOAA) prior to 1970 are now being funded under the IDOE Environmental Forecasting Program.

Ships of Opportunity: Time-Series Expendable Bathythermograph Sections, Tropical and North Pacific Ocean

This NOAA National Marine Fisheries Service project is part of the integrated Pacific Air-Sea Study, conducted by scientists on the Pacific Coast to study many aspects of large-scale, air-sea interaction in the Pacific Ocean on a long-term, time-continuous basis. The scientific objective of the NOAA project is to identify and describe seasonal and year-to-year changes of temperature and circulation in major currents of the Equatorial and North Pacific Ocean.

IDOE is supporting a 3-year program to obtain ocean salinity, surface temperature, temperature-vs-depth (expendable bathythermograph), and weather observations aboard merchant ships (ships of opportunity). For this purpose, those ships are selected whose routes give repetitive crossings essentially following the prevailing direction of the major currents (fig. 23). Ships sailing four routes—radiating from Honolulu to Cook Inlet, Samoa, San Francisco, and Yokohama—will provide sections across the California Current, Kuroshio, North Pacific Drift, and equatorial currents, respectively. A ship sailing from Los Angeles to Tahiti will prove additional transequatorial sections.

Temperature-vs-depth observations are digitized automatically aboard ship for radio transmission of BATHY (bathythermograph) messages to the Navy, for computer processing in scientific analyses, and for archiving the data at the National Oceanographic Data Center. The 3-year project will form a base of information and experience for further development for oceanwide environmental monitoring and forecasting.

In addition to the cruises by the SS *Californian* and *Oregon Standard* (listed in the Appendix), expendable bathythermograph data have been obtained between Honolulu and San Francisco, and Honolulu and Japan, by the following ships of opportunity:

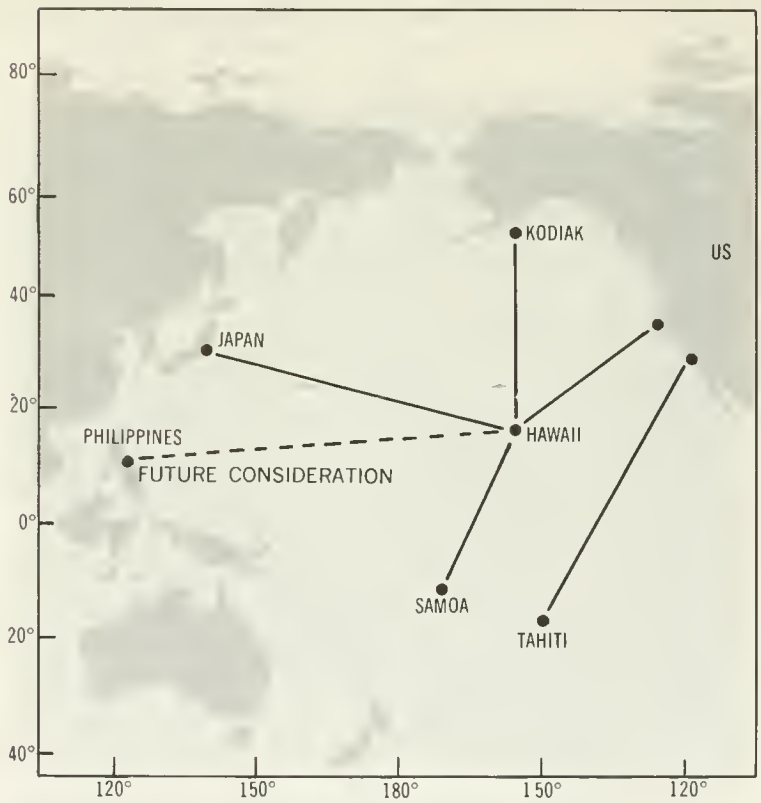


FIGURE 23.—Ships of Opportunity: Time-Series Expendable Bathythermograph Sections, Tropical and North Pacific Ocean.

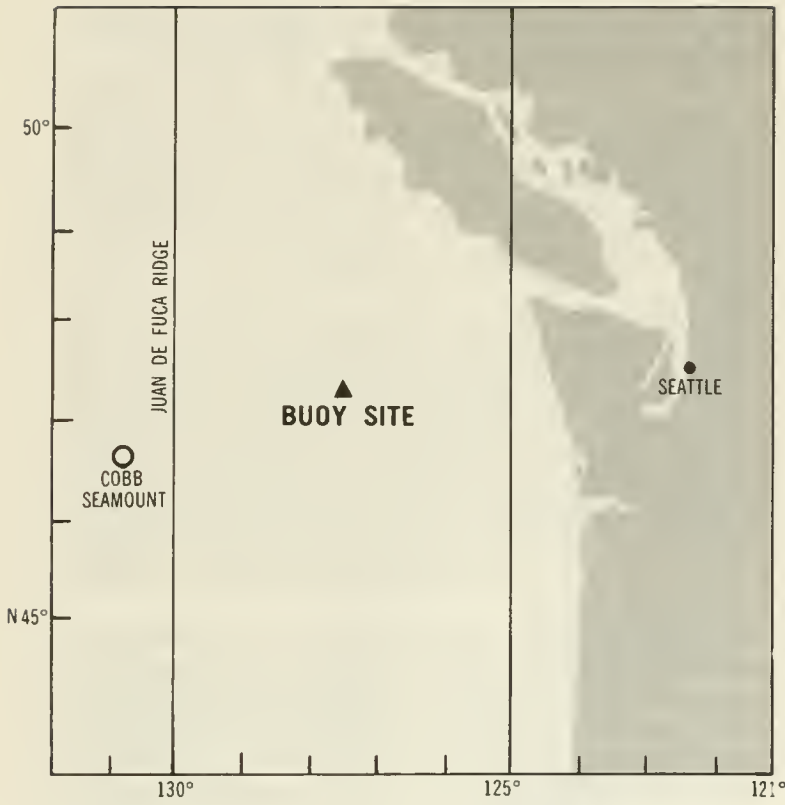


FIGURE 24.—Site of the Pacific Oceanographic Laboratories Near-Surface Circulation Studies.

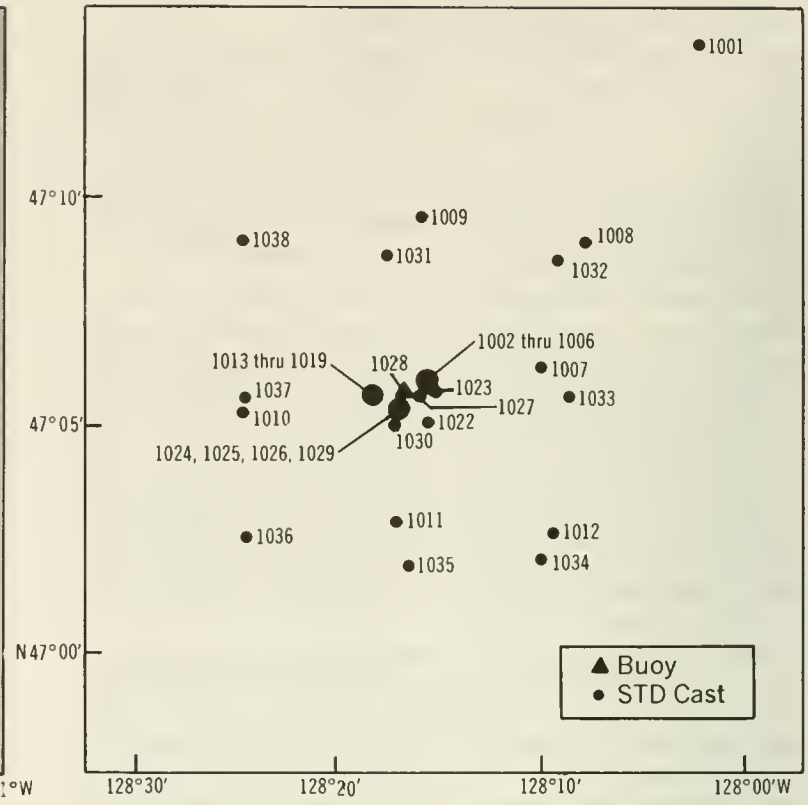


FIGURE 25.—Location of the STD casts. Casts 1001 to 1019 were measured between August 3 and 6, 1971, the others on September 5 and 6, 1971.

Honolulu and San Francisco	
Hawaiian Enterprise, Voyage 32W	November 8-11, 1971.
" 33	November 23-27, 1971.
" 34	December 4-10, 1971.
" 35W	December 24-28, 1971.
President Cleveland, Voyage 190	November 14-15, 1971.
SS *Californian*, Voyage 207	October 20-24, 1971.
Honolulu and Japan	
Michigan, Voyage 12	October 1-8, 1971.
President Cleveland, Voyage 190	October 2-10, 1971.
Nevada Standard, Voyage 554	November 21-26, 1971.

Near-Surface Circulation Studies

The NOAA Pacific Oceanography Laboratory (POL), Seattle, Wash., obtained data on the structure of the oceanic surface boundary layer (near-surface circulation studies) at about 47.2°N., 127.7°W., (fig. 24) in August and September 1971. POL studied the response of the thermocline region to the strong intertial currents generated in the mixed layer by the action of a local wind.

A Richardson buoy was moored in the Caseadia Basin of the northeast Pacific using the mooring method and hardware tested by the Woods Hole Oceanographic Institution. Recorded were: (1) Wind speed and direction; (2) water speed and direction in the mixed layer, in the thermocline region, and beneath the thermocline; (3) air temperature; (4) water temperature in the mixed layer, in the thermocline region, and beneath the thermocline; (5) water pressure; and (6) dynamic topography of the surrounding area and vertical distribution of Brunt-Vaisala frequency near the moored buoy.

A salinity-temperature-depth survey of the area surrounding the buoy was completed after its mooring (fig. 25) and repeated before its recovery, to provide a record of horizontal distribution of density (dynamic topography) and vertical distribution of density (Brunt-Vaisala frequency) at the site.

Air-Sea Interaction and Mixed Layer Project

The Mixed Layer Project is one of two IDOE projects conducted by NOAA's Atlantic Oceanographic and Meteorological Laboratories. The objectives of this project are to study: (1) The total heat exchange across the air-sea interface on a diurnal or smaller time scale as inferred from the total heat budget of the oceanic mixed layer; and (2) the vertical structure of the temperature, salinity, and current fields in the mixed layer of the ocean in relation to vertical heat transfer processes and mixing.

To achieve these objectives, a number of instrumentation systems were used. Two MAMOS-type buoys were deployed; 28-foot parachutes at a depth of 30 m. were used. One buoy was instrumented with a quartz-thermometer system that recorded temperatures at 1-min. intervals for depths of 10, 20, 30, 40, and 50 m. on a digital magnetic tape recorder. The other buoy recorded air temperature, humidity, sea-surface temperature, and wind speed on digital magnetic tape.

The buoys were deployed by the OSS *Discoverer* at about 21°N., 64°W., on September 28, 1971. The experiment ended October 31, 1971.

Circulation Studies—CICAR

NOAA's Atlantic Oceanographic and Meteorological Laboratories (AOML) conducted another field project under IDOE with emphasis on studies to be done under the auspices of the International Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR) Program. These studies concentrated on tidal phenomena and the development and application of Lagrangian methods of current measurement in the CICAR region.

Subproject: Tides in the CICAR Region. Coastal and pelagic measurements and near-bottom current measurements were made to obtain more accurate transport calculations, to study the variability of currents at the entrance to the Caribbean, and to provide a prototype for the international deep-sea tide program.

By the completion of the first year, AOML scientists for 1 month (September-October 1971) deployed and recovered two pelagic pressure and near-bottom current measuring systems in the eastern Caribbean. They also for 1 month (July-August 1971) deployed and recovered two shallow capsules (current meter temperature sensor and tide gage) in the western Caribbean.

Data obtained were tide records for 1 month at 4-km. depth near the M_2 amphidrome; near-bottom current records at both locations; and two 1-month shallow tide gage records in the western Caribbean.

Subproject: Lagrangian Measurements of Ocean Currents. The purpose of this project is to determine the nature and evaluate the extent of the ageostrophic components of flow in the western Caribbean where the Yucatan Current forms. Measurements will be made of the acceleration of parcels tagged by drift buoys in relation to the surrounding mass distribution.

Field work completed in the western Caribbean included tracking sets of near-surface drogue-buoys, approximately along the paths indicated in figure 26. Nansen bottle, bathythermograph (BT), and conductivity-temperature-depth data were obtained along these tracklines by the RV *Researcher*. This ship also made two expendable bathythermograph (XBT) surveys to determine the initial drogue deployment position and spent 3 nights making BT sections and tracking drogue buoys in the vicinity of Swan Island. The NOAA ship RV *Discoverer* made salinity-temperature-depth and rosette multi-sampler measurements along many tracks in the western Caribbean. The RV *Eastward* used XBT probes, supplied by AOML, to obtain measurements in the Yucatan Channel.

In the Gulf of Mexico, three to five shallow parachute drogues were deployed on August 26, 1971, in the region where the Florida Current was forming, about 100 km. north of the axis of the Yucatan Strait. The drogues were tracked for 5 days over a distance of 520 km. in a sinusoidal path.

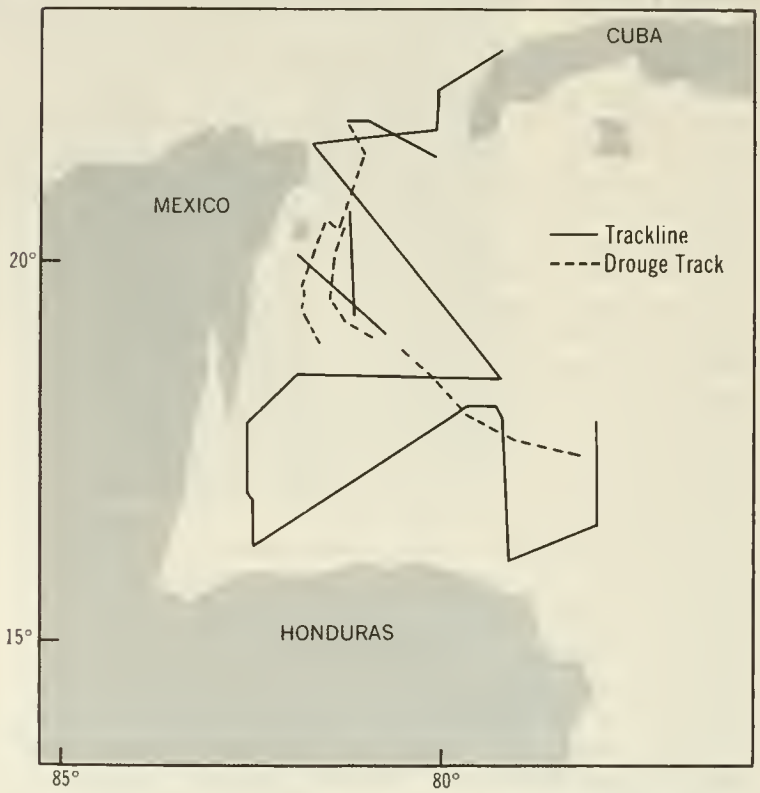


FIGURE 26.—Tracklines and drogue tracks by RV *Researcher* in western Caribbean, July 1971.

Zooplankton were also gathered during CICAR studies involving NOAA's *Discoverer* and *Oregon II* and the Mexican research vessel *Uribe*.

Seabed Assessment Program

The goals of the Seabed Assessment Program are to expand activities in gathering data on the geological structures and sedimentary distributions of the continental margins, dynamic properties of the ocean floor, and chemical and physical processes of the deep ocean, particularly those which relate to potential economic resources. In addition to a better understanding of the earth itself, understanding of these ocean characteristics will prove valuable in locating new resources in unexplored areas.

The continental margins now produce 15 percent of the world's supply of petroleum. As our resources on land decline, this percentage should increase. In addition, hard mineral, salt, sulfur, and placer deposits are potential new resources. The continental margins remain largely unexplored outside the areas adjacent to the economically more developed North Atlantic countries.

Detailed studies of the continental margins around the South Atlantic Ocean are now underway. Included are the Eastern Atlantic Continental Margin Study of the area from Capetown, South Africa, to Portugal and the Southwestern Atlantic Continental Margin Study of the areas adjacent to Argentina and Brazil. Simultaneous study of these areas has broad scientific appeal. The currently accepted "fit" of the continents made by Bullard and others suggests that the original continental breakup and subsequent drifting must have been relatively straightforward in the South Atlantic, thus making this area an ideal location to test hypothetical models. The South American coastline has numerous ridges and open-ended basins trending perpendicular to the coastline with counterparts at conjugate positions on opposing margins of Africa. Results and interpretations from carefully conducted investigations of the South Atlantic margins are applicable to other continental limits.

K. O. Emery, Woods Hole Oceanographic Institution (WHOI), is the Principal Investigator for the Eastern Atlantic Continental Margin Study. Scientists from countries along the west coast of Africa and Portugal are participating in various legs of the cruises that began in 1972. Field work will be completed in 1973; final publication of results is scheduled for 1974.

Special mention should be made of K. O. Emery's unpublished manuscript, Woods Hole Oceanographic Institution 72-54, *Eastern Atlantic Continental Margin Program of the International Decade of Ocean Exploration (GX-28193), Some Results of 1972 Cruise of RV "Atlantis II."* This paper (funded under the Seabed Assessment Program) describes a geophysical cruise to the southeastern Atlantic during which a large ancient delta of the Orange River and a diapiric field off Angola were mapped. These geographic features, which may have future economic oil potential, began development during early stages of the separation between Africa and South America.

Emery and his associates prepared most of the report before the *Atlantis II* returned to port in July 1972; printed copies were distributed that same month. Emery's effort emphasizes how rapidly scientific information can be disseminated.

G. Bryan, Lamont-Doherty Geological Observatory (L-DGO), is coordinating the Southwestern Atlantic Continental Margin Study. The geophysical data-gathering program off Argentina is completed, and work off Brazil will begin in 1973. Petrobras, the Brazilian National Oil Company, is funding WHOI scientists to carry out a detailed study of the shallow waters along the Brazilian coast beginning in late 1972. After finishing his work off the west coast of Africa in 1975, K. O. Emery plans to make geophysical observations along tracklines from the African coast to the Mid-Atlantic Ridge, thereby tying the two Studies together.

Several geophysical surveys in the mid-Atlantic and on the continental margins of some countries in the Gulf of Mexico-Caribbean Sea region and off the coast of Liberia were completed in 1971 by the United States Geological Survey (USGS) and NOAA. Data from these surveys are now being analyzed.

Lithospheric plate boundaries, including the midoceanic ridges and deep trenches, are the areas of most tectonic activity. Heavy metals are believed to rise to the surface along these ridges and move toward the deep trenches. These metals, riding on the top of the subducting lithospheric plate, are concentrated into major ore deposits (in regions landward of trenches) above the descending plate by complex distillation processes. The Nazca Lithospheric Plate off the coast of Peru and Chile has been recognized as an excellent example for detailed investigation of the complete metalliferous cycle—from crustal formation along the East Pacific Rise to its consumption in the Peru-Chile Trench. The major copper, molybdenum, and tin deposits in the Andes are considered to be the cycle's end products.

The Nazca Plate is being studied in a cooperative program involving the Hawaii Institute of Geophysics (HIG), Oregon State University (OSU), and the Pacific Oceanographic Laboratory (POL) of NOAA. The principal investigators are G. Woollard (HIG), L. Kulm (OSU), and R. Burns (POL). Scientists from Chile, Colombia, Ecuador, and Peru are also participating in this study. The first cruises were completed in 1971 by the RV *Kana Keoki* of HIG and RV *Yaquina* of OSU. Field work will continue through 1975, with data analysis taking place in 1975-78.

The East Pacific Rise extends northward into the Gulf of California, where it is now under study by scientists from the Scripps Institution of Oceanography and the University of Mexico. This area is analogous to the Red Sea area, where heavy metals have been detected in the hot brines.

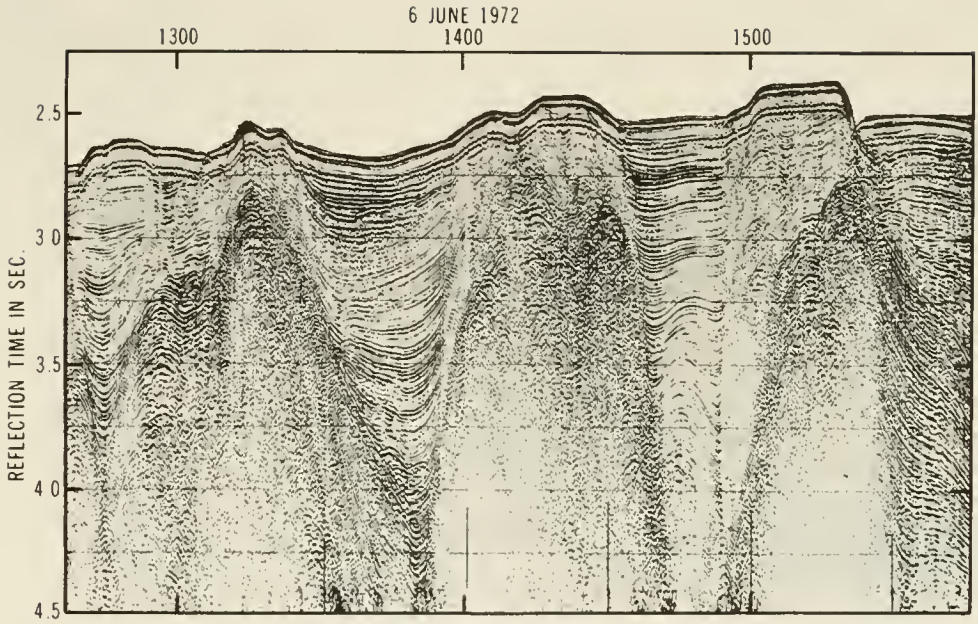
IDOE is also supporting a research program on the Mid-Atlantic Ridge. As a first step, scientists from France and the United States are planning extensive exploration of the ridge by use of submersibles. Dives will begin in 1974.

The widespread occurrence of manganese nodules, particularly on the deep ocean floor, is also being studied. Although this occurrence has long been known, no systematic studies have ever been made. IDOE is supporting a study which will bring together the present knowledge on: (1) The origin and distribution of the nodules, (2) technological problems that must be solved before mining becomes economical, (3) environmental impact of mining the abyssal depths of the ocean, and (4) legal status of a mining operation beyond the limits of any claims to offshore sovereignty. A coordinating office has been set up at Lamont-Doherty Geological Observatory.

Upon completion of the manganese nodule study, the Seabed Assessment Program will support new research related to the origin and distribution of the nodules. The results of these investigations are expected to provide a basis for research by other agencies.

SURVEYS AND DATA ANALYSIS

During 1971, nine separate Seabed Assessment studies, involving 90,000 nautical miles of marine geophysical surveys by research



Emery's Seismic reflection recordings reveal diapirs south of the Congo Canyon.

Table 1.—IDOE geophysical cruises completed during 1971

Agency, project, and principal investigator	Ship	1971 dates	Mileage of records: Gravity	Magnetics	Seismic	Bathymetry	Bottom samples: Dredge	Core	Sono buoy
USGS geophysical surveys:			Nautical miles				Number		
Leg 1, Campeche—G. W. Moore	**Unitedgeo I**	May 27-June 17	3,800	3,800*	3,800*	3,800*	1	—	2
Leg 2, Yucatan—J. G. Vedder	**Unitedgeo I**	June 19-July 14	2,800	2,800*	2,400*	2,400*	7	—	1
Leg 3, Greater Antilles—L. E. Garrison	**Unitedgeo I**	July 17-Aug. 4	3,000	3,000*	3,000*	3,000*	1	—	3
Leg 4, Venezuela Borderland—E. A. Silver	**Unitedgeo I**	Aug. 18-Oct. 1	4,200	4,200*	4,200*	4,200*	—	—	2
Leg 5, Liberian Margin—J. S. Schlee	**Unitedgeo I**	Oct. 30-Nov. 20	2,900	2,900*	2,900*	2,900*	3	—	5
Leg 6, Atlantic Crossing West—M. F. Kane	**Unitedgeo I**	Nov. 24-Dec. 9	3,400	3,400*	3,000*	3,400*	—	—	18
NOAA geophysical surveys:									
Pacific SEAMAP—H. Orlin	**Surveyor**	June 8-Nov. 24	36,600*	36,900*	7,300*	37,100*	—	—	—
Trans-Atlantic Geotraverse (TAG)—P. A. Rona	**Discoverer**	April 16-June 17	14,100	14,300	800	15,100	27	12	8
Caribbean-Atlantic Geotraverse (CAG)—G. Peter	**Researcher**	Sept. 18-Nov. 18	18,000*	18,200*	1,700*	18,200*	—	—	—
Totals:			88,800	88,500	29,100	29,100	39	12	39

* Data now available at Marine Geology and Geophysics Group, NGSDC, EDS, NOAA.

FIGURE 27.—USGS 1971 *Unitedgeo I* surveys: Leg 1, Bay of Campeche, and Leg 2, Margin of the Yucatan Peninsula.

ships, were completed by the U.S. Geological Survey (USGS) and NOAA. These studies were made as part of both continental margin and sea floor dynamics projects. Underway bathymetry, gravity, magnetics, and seismic reflection data were collected, and cores, dredges, and sonobuoy records were obtained on several cruises. Satellite navigation was used for position control on each cruise. Table 1 summarizes the trackline miles of geophysical data and related samples obtained during each study.

In addition to the NOAA and USGS geophysical surveys, several other institutions started work on Seabed Assessment studies in 1972; projects were initiated that included compiling, evaluating, and reformatting geological and geophysical data collected during previous years by various institutions.

The following description of each completed study is based on data reports, abstracts, and other information received from principal investigators.

USGS *Unitedgeo I* Surveys

The work performed by the USGS consisted of six projects, each designed to study a different problem and each limited to separate legs of an ocean survey completed by the chartered ship *Unitedgeo I*. The six legs of the cruise were completed between June and December 1971. USGS has published data reports containing copies of the acoustic reflection records for the six legs (see Seabed Assessment Bibliography).

Leg 1, Bay of Campeche. This survey was made in the southern part of the Bay of Campeche; an east-west trackline spacing of about 9 km. was used (fig. 27). The region covered includes the north-trending sedimentary folds in the western part of the survey area and a province of salt domes in the eastern part.

Results to date include: (1) Correlation of prominent fold axes and faults from track to track in the western part of the survey, (2) evidence that the late Cenozoic Mexican volcanic belt apparently ends abruptly on the continental shelf of the Bay, and (3) evidence of salt intrusions (salt domes and anticlines) both inside and outside the main tectonic belts.

Leg 2, East Margin Yucatan Peninsula. This study (fig. 27) was made along the coasts of Mexico and British Honduras. The objectives were to study the structural evolution of the continental margin east of the Yucatan Peninsula and to determine the history and relationships of tectonic features, including the Yucatan Basin and the Cayman Ridge and Trough. The possibility of stratigraphic links between Cuba and the Yucatan Peninsula was also explored.

Results to date include: the obtaining of critical information (as a result of dredging) about the types of rocks and sediments that form major sea floor features, and the identification of an elongate set of ridges parallel to the continental border. (These ridges appear to be belts of relatively resistant metamorphosed sedimentary rocks bordering an elongated basin partially filled with sediments.)

Leg 3, Eastern Greater Antilles. This survey (fig. 28) was made in a region of the Atlantic Ocean and Caribbean Sea that includes the Muertos Trough (south of Puerto Rico), the Anegada Trough (where several linear tectonic elements seem to meet), and an area where the faulting associated with the Puerto Rico Trench appears to change from underthrusting to strike slip faulting.

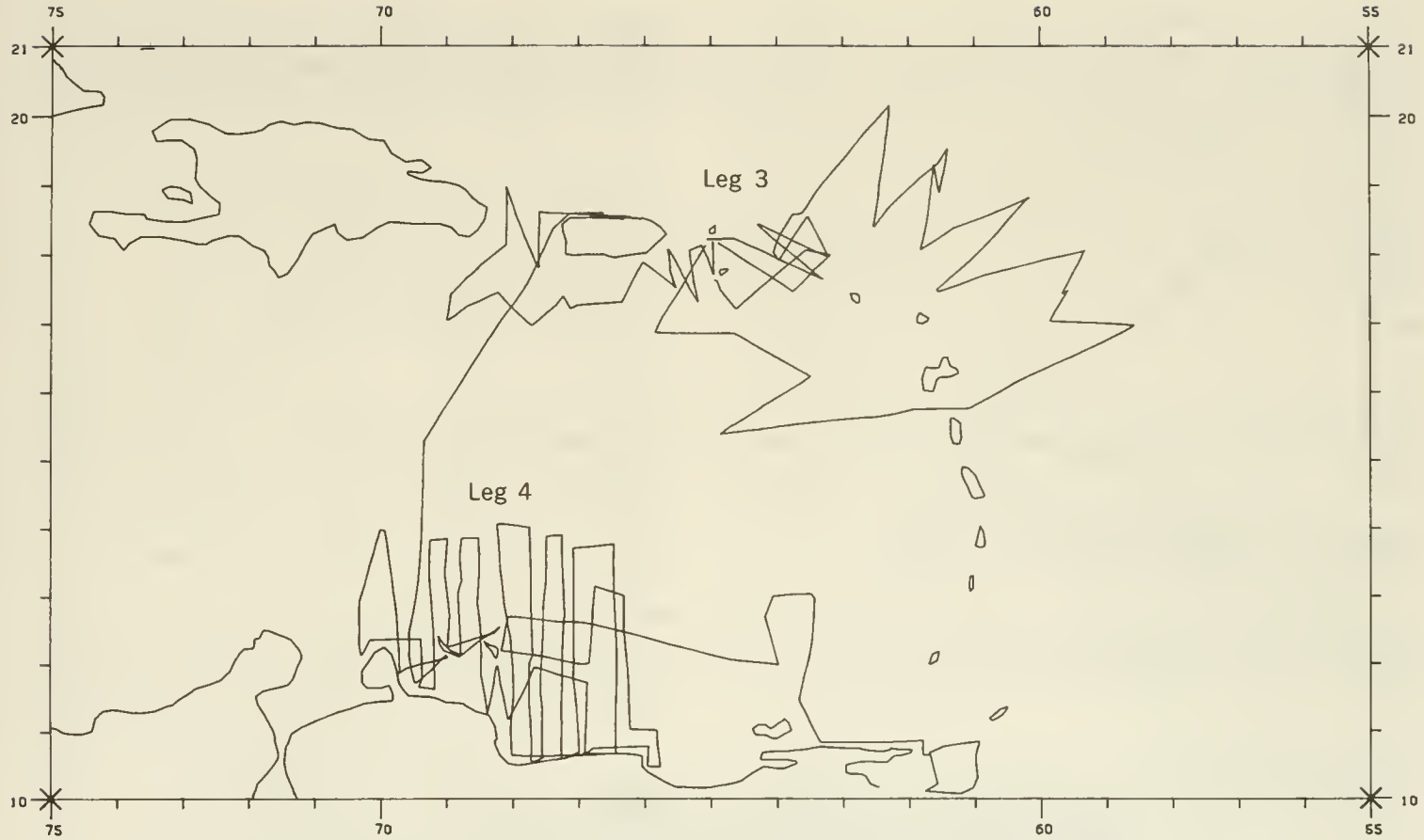


FIGURE 28.—USGS 1971 *Unitedgeo I* surveys: Leg 3, Eastern Greater Antilles, and Leg 4, Venezuelan Continental Border.

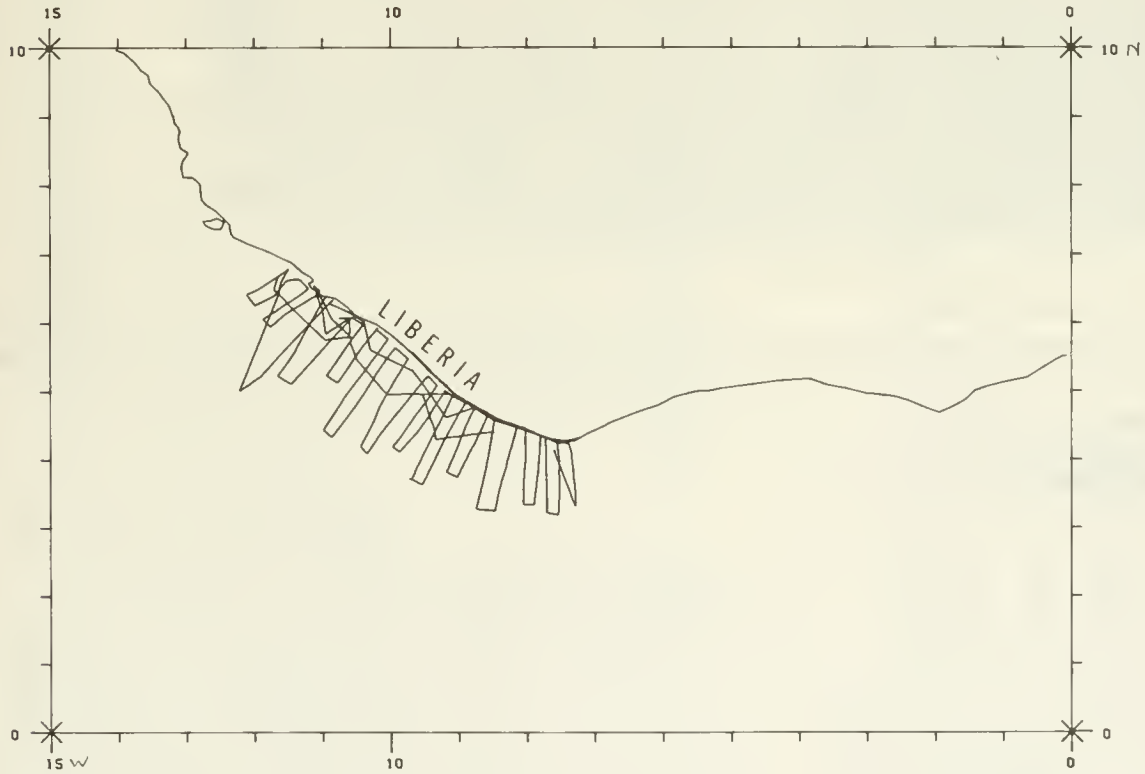


FIGURE 29.—USGS 1971 *Unitedgeo I* surveys: Leg 5, Continental Margin off Liberia.

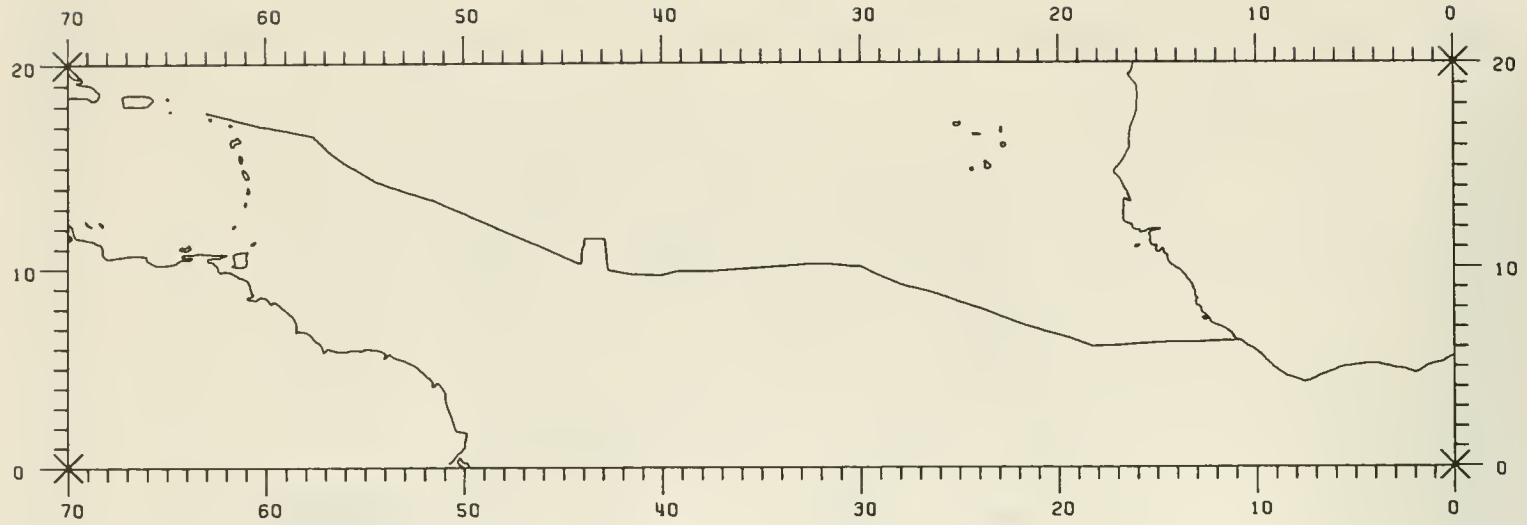


FIGURE 30.—USGS 1971 *Unitedgeo I* surveys: Leg 6, Liberia to Puerto Rico.

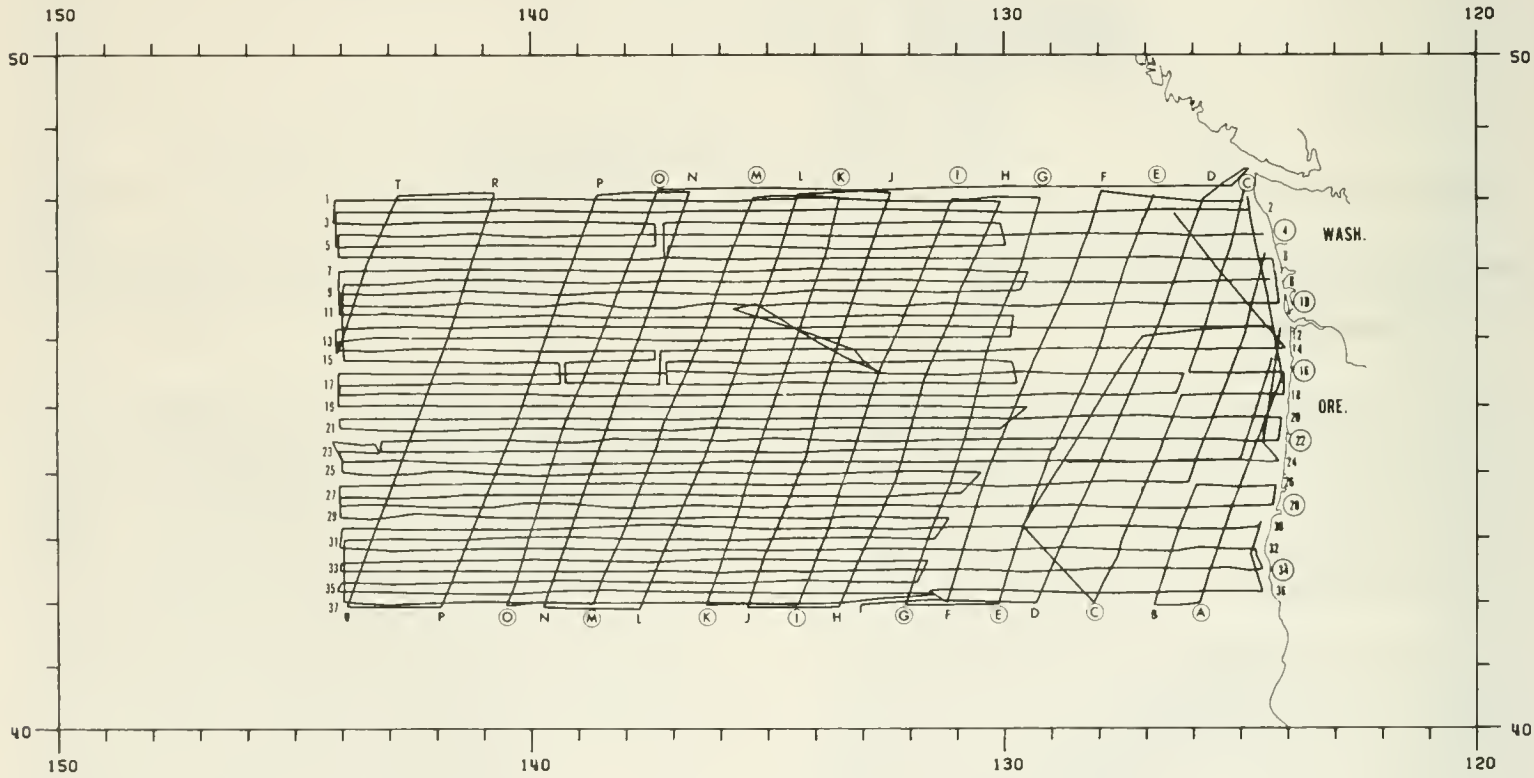


FIGURE 31.—NOAA National Ocean Survey 1971 tracklines by *Surveyor*. Seismic profiling lines are designated by solid circles at end of lines.

Results to date include evidence that tensional faulting or forces exist south of Puerto Rico and in the Anegada Trough area and that oceanic reflectors continue for several kilometers beneath the outer toe of the Antillean structure in the northeastern part of the survey area.

Leg 4, Venezuela Continental Borderland. This investigation was made along the coast of Venezuela (fig. 28) and included the Islands of Aruba, Bonaire, and Curacao, as well as the Bonaire Trough, Curacao Ridge, and Los Roques Trough. The basic objectives were to: (1) determine structural relationships of the various tectonic features, (2) determine the nature of specific plate boundaries, and (3) outline areas of potential mineral resources on the continental shelf and slope.

Results to date include: (1) Evidence suggesting that the Islands of Aruba, Bonaire, Curacao represent an area of raised oceanic rocks; (2) findings that in places the basaltic or diabasic layer "B" can be traced southward beneath the deformed deposits of the continental slope; and (3) detection of intensely deformed sedimentary rocks under the E-W trending Curacao Ridge.

Leg 5, Continental Margin of Liberia. This survey complemented previous work carried out on land by the USGS and the Liberian Geological Survey. The purpose of the survey was to investigate the structural-stratigraphic framework of the continental margin adjacent to Liberia. Of particular interest is the nature of transition of the Precambrian shield area from land to ocean. The tracklines were mostly perpendicular to the coastline and extended about 200 km. offshore to water depths in excess of 4 km. (fig. 29).

Results include: (1) A 100 to 400 gamma magnetic anomaly along the outer edge of the continental shelf has been detected; (2) faulting and slumping, as revealed by seismic reflection profiling, when combined with relatively large magnetic anomalies, suggest that a major deep-sea fracture zone intersects the West African margin in the area of Cape Palmas; and (3) a relatively thick accumulation of sediments on the continental slope west of 9°W. probably reflects an earlier separation time of the African margin from North America (west of 9°W.) than from South America (east of 9°W.).

Leg 6, Transatlantic Crossing, West Africa to Virgin Islands. This leg, which was run between Monrovia, Liberia, and Charlotte Amalie, St. Thomas, U.S. Virgin Islands, (fig. 30) included continuous acoustic reflection profiles across three drill sites of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) program and several structural features including the Mid-Atlantic Ridge and the Vema Fracture Zone. Potential results from this cruise will include: (1) Construction of structural models of the Vema Fracture Zone, (2) correlation of oceanic seismic reflection profiles with JOIDES drilling results over a greater extent than previously possible, (3) investigation of the structure of the Sierra Leone Ridge, (4) extension of knowledge of sediment distribution and thickness in the deep ocean, and (5) studies of crustal sound velocity.

NOAA Surveys and Data Analysis

The NOAA work in 1971 involved three separate studies. In the northeast Pacific Ocean, a Scientific Exploration and Mapping Program (SEAMAP) survey was made west of Washintgon and Oregon by the NOAA ship OSS *Surveyor*. In the Atlantic, work was continued on the Trans-Atlantic Geotraverse (TAG) by the OSS *Discoverer*, and the Caribbean-Atlantic Geotraverse (CAG) was initiated by the OSS *Researcher*.

Pacific SEAMAP. Tracklines run by the OSS *Surveyor* during 1971 west of Oregon and Washington were basically oriented east-west, with an 18-km. spacing, supplemented by crosslines (fig. 31). Seismic reflection results were obtained on every sixth E-W line and on about every other north-trending crossline. The area covered is very promising from the viewpoint of plate tectonics; also, during the unraveling of the complexities of this area, light will probably be shed on the structure and history of the seismically active and destructive San Andreas fault system to the southeast.

Included in the survey area are two centers of sea floor spreading (the Gorda Rise and the Juan de Fuca Ridge), seismically active transform faults (including the Blanco Fracture Zone), and inactive fracture zones (such as the Sedna and Surveyor). Results from the seismic reflection data show a buried trench close to the Oregon-Washington coast, adjacent to the string of active volcanoes that runs along the crest of the Cascade mountains from northern California to British Columbia.

The magnetic anomalies in this area trend mostly north-south and can be correlated very well from trackline to trackline on the 37 east-west lines. This correlation will allow the solution of many structural problems, such as apparent offsets of magnetic anomalies across fracture zones. This study includes part of the classical "Mason-Raff" survey area and extends to 144°W.

Free air gravity anomalies, with a precision of 2 to 3 mgals. r.m.s., were obtained over the survey area. Significant results include: (1) Finding of negative values in the range of minus 50 to minus 80 mgals. along the base of the continental margin in the area of the above-mentioned thick-sediment fill, and (2) finding of a range of 80 mgals. (mostly negative) measured along the Blanco Fracture Zone.

Additional results include evidence that the Juan de Fuca Ridge is now rising; this rise may result in the eventual emergence of the Bear and Cobb Seamounts as islands. Also, examination of narrow-beam echosounder records reveals the presence of a complex pattern of deep-sea channels in the Tufts Abyssal Plain.

Pacific SEAMAP bathymetry, magnetic, and gravity data collected in the North Central Pacific during and after 1961 were reformatted and evaluated by the Marine Sciences Institute (MSI)

Table 2.—Pacific SEAMAP 1961-70 data reports

NOAA Technical Report	SEAMAP area numbers	Data printout pages	Data points	Magnetic observations	Gravity observations	Available maps	
						LNI[1]	B-M-G[2]
NOS 45	15524-10	275	21,968	13,429	3,151	X	X
NOS 46	15530-10	245	19,582	11,300	2,169	X	X
NOS 47	15248-14	229	18,319	8,917	3,251	X[3]	X[3]
	15254-14	45	3,537	1,246	602	—	—
NOS 48	16648-14	196	15,613	9,899	2,048	X[4]	X[4]
	16654-14	5	376	136	58	—	—
NOS 49	16530-10	124	9,854	6,017	708	X	X
	17530-10	26	2,063	874	106	X[5]	—
NOS 50	16524-10	204	16,267	10,410	2,011	X	X
	17524-10	39	3,073	1,410	135	X[5]	—
NOS 51	15636-12	206	16,435	7,486	1,574	X	—
	15642-12	172	13,692	6,680	2,186	X	—
	16836-12	83	6,617	2,948	422	X	—
	16842-12	40	3,174	1,457	514	X	—

[1] Logical Number Index map to guide user from number on map to respective entry in data listing.
[2] Bathymetry, magnetic anomaly, and gravity anomaly maps are being compiled by NOS (available separately).
[3] Map for area 15248-14 extended to include data in area 15254-14.
[4] Map for area 16648-14 extended to include data in area 16654-14.
[5] Longitude 180° is western limit of area.

of the University of Connecticut. MSI worked under contract to NOAA's National Ocean Survey (NOS), who used IDOE funds to support the project. More than 250,000 evaluated data points have been compiled into NOAA Technical Reports, NOS 45 through NOS 51 (table 2), that are available from Code D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, D.C. 20235.

The reports present the data in computer printout format and include index maps that provide access to all data points in the listings for any given geographic area. Table 3 shows survey ships and year of data collection. Figure 32a delineates Pacific SEAMAP areas for which 1961-70 evaluated data are available. Figure 32b delineates those areas for which the National Ocean Survey is compiling contour maps of bathymetry, gravity anomalies, and magnetic anomalies.

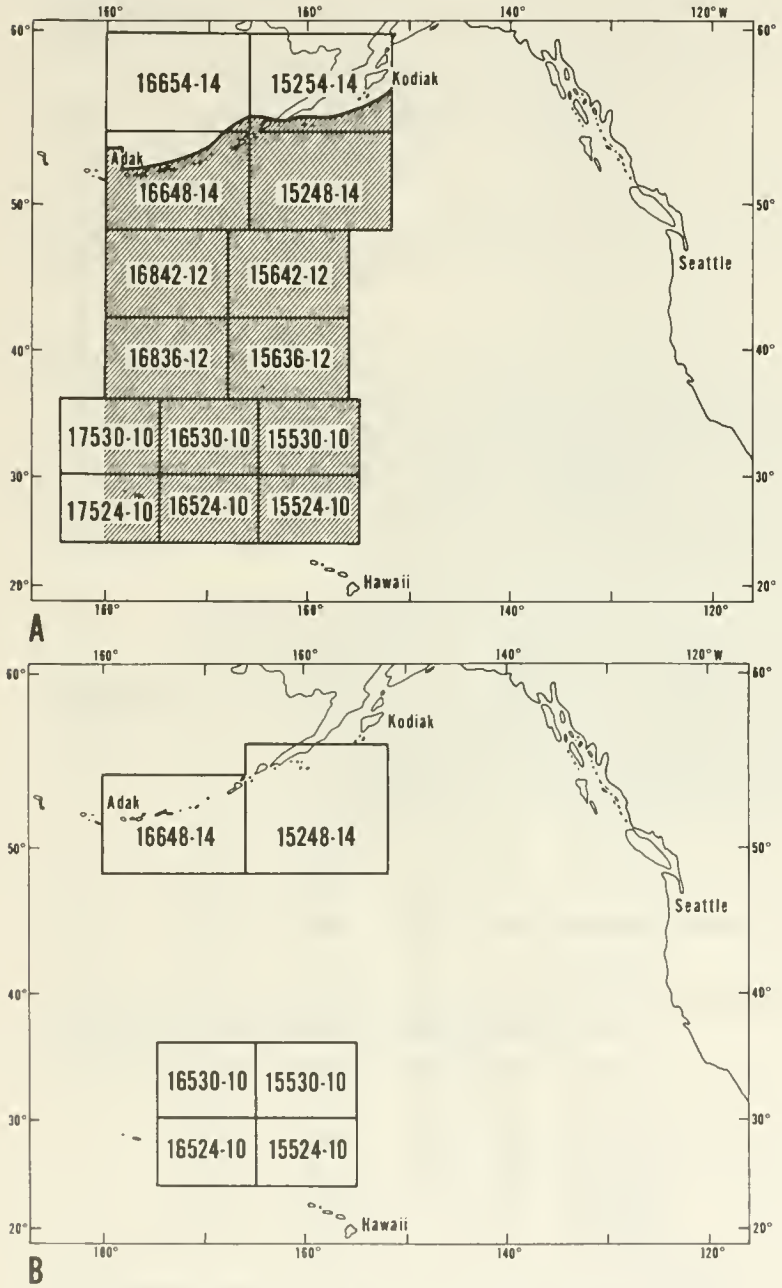


FIGURE 32.—Pacific SEAMAP Areas: (A) For which 1961-70 evaluated data in table 2 are available; and (B) for which contour maps of bathymetry, magnetic anomalies, and gravity anomalies are being compiled.

Table 3.—Pacific SEAMAP 1961-70 data acquisition by ship and year

SEAMAP area and ship	Years of data collection—North Central Pacific									
	61	62	63	64	65	66	67	68	69	70
Area 15524-10										
Pioneer	x	x	x		x					
Surveyor			x	x		x	x		x	x
Area 15530-10										
Pioneer	x	x	x		x					
Surveyor				x		x	x		x	x
Area 15248-14										
Pioneer	x	x	x							
Surveyor			x	x		x	x			
Area 15254-14										
Pioneer	x	x	x							
Surveyor			x	x		x				
Area 16648-14										
Pioneer	x		x							
Surveyor			x	x						
Area 16654-14										
Pioneer										
Surveyor			x	x						
Area 15636-12										
Pioneer	x	x	x		x					
Surveyor			x	x		x	x		x	
Area 15642-12										
Pioneer	x	x	x							
Surveyor				x		x	x		x	
Area 16836-12										
Pioneer	x									
Surveyor			x							
Area 16842-12										
Pioneer	x									
Surveyor			x							
Area 16530-10										
Pioneer			x							
Surveyor			x		x					
Area 17530-10										
Pioneer	x									
Surveyor			x							
Area 16524-10										
Pioneer	x		x							
Surveyor			x		x					
Area 17524-10										
Pioneer	x									
Surveyor			x							

Trans-Atlantic Geotraverse (TAG). This is a study of the corridor between Cape Hatteras, North America, and Cap Blanc, Africa (fig. 33). Its principal objective is to establish a standard crustal section, about 3° in width, across the central North Atlantic between these two points, which are considered to have been joined before North America separated from Africa.

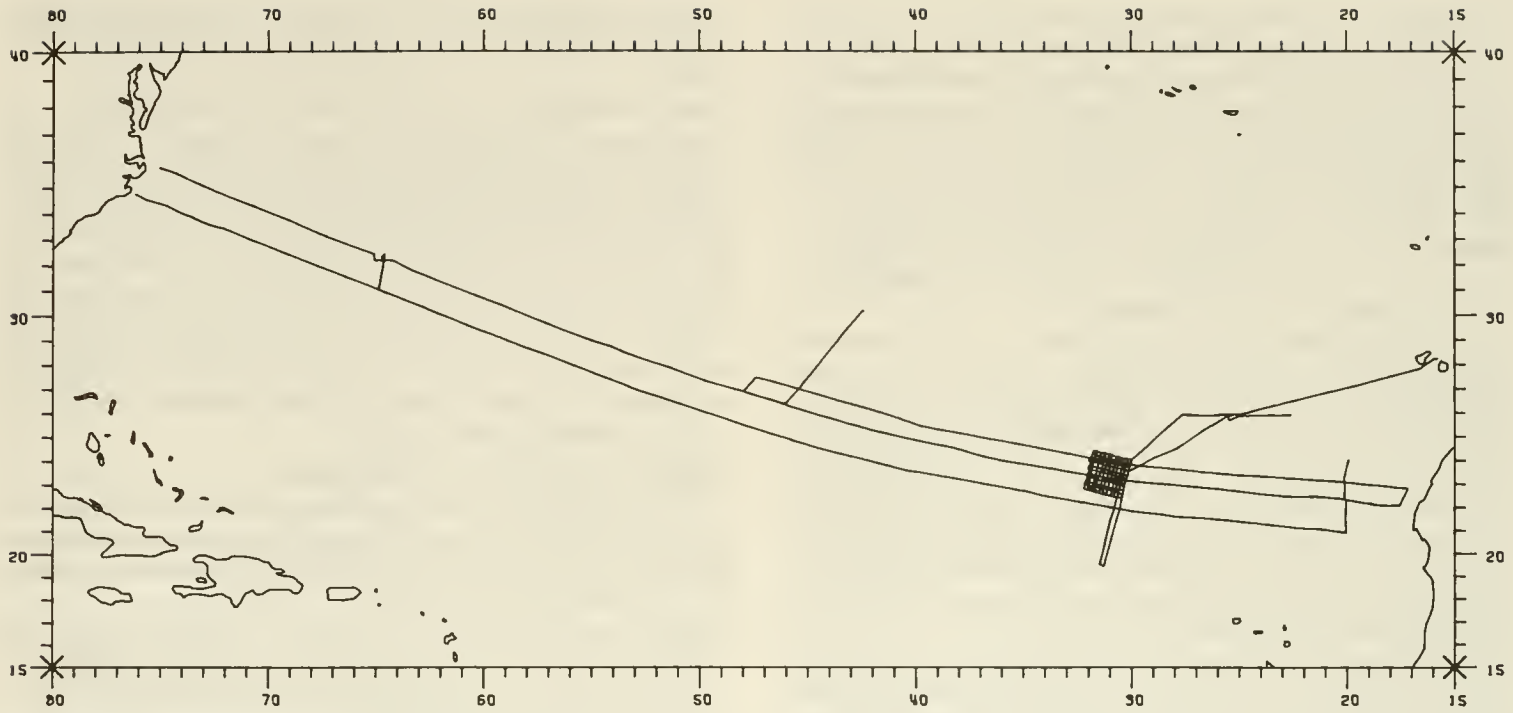


FIGURE 33.—NOAA Atlantic Oceanographic and Meteorological Laboratories Trans-Atlantic Geotraverse.

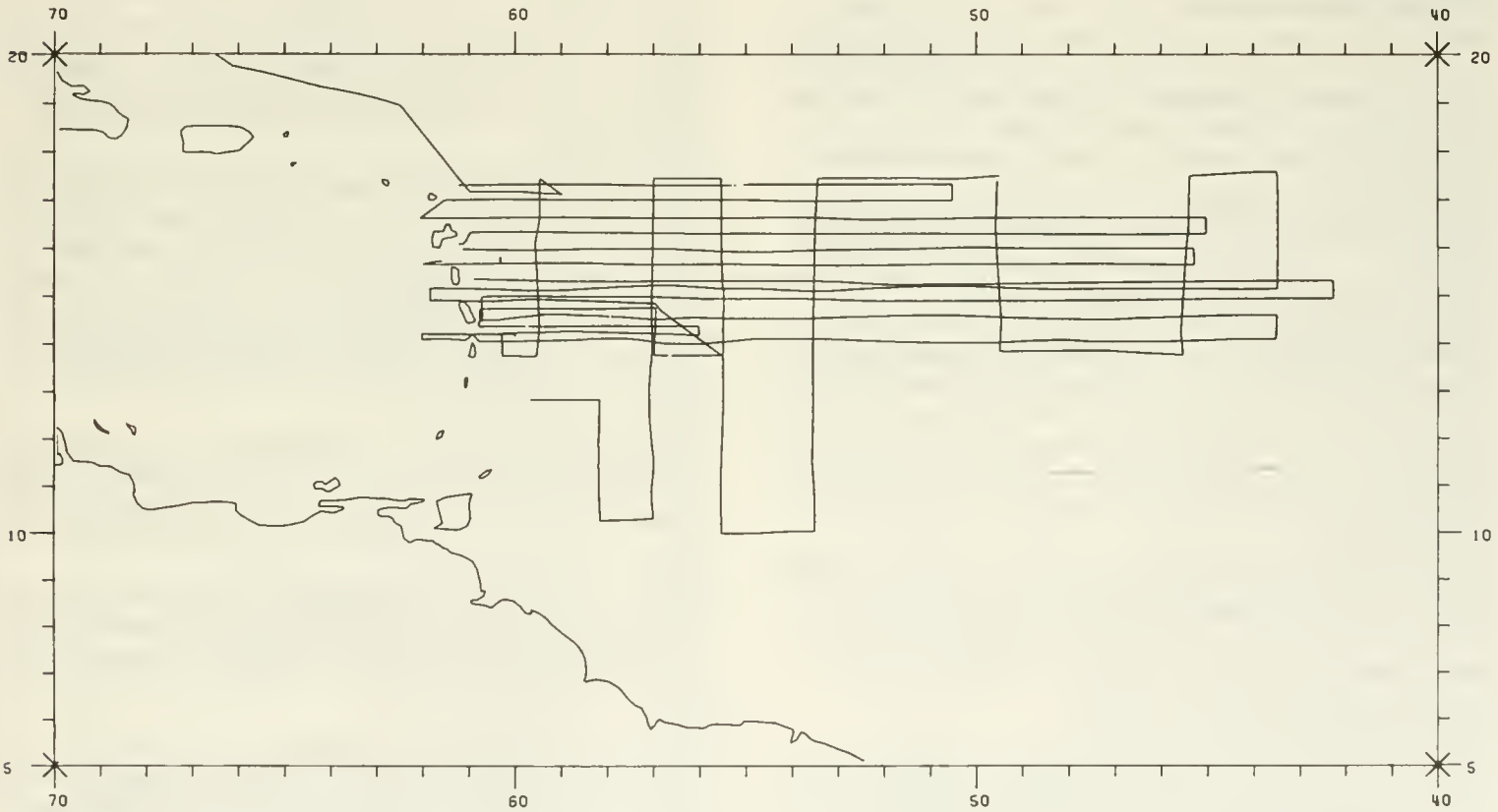


FIGURE 34.—NOAA Atlantic Oceanographic and Meteorological Laboratories Caribbean Atlantic Geotraverse.

Relatively closely spaced tracklines were run in 1971 in the TAG corridor. When combined with previous results, the 1971 data allow a standard sequence of magnetic reversal anomalies to be deduced for the central North Atlantic. This sequence can be traced back 60 million years on either side of the Mid-Atlantic Ridge, showing that rates for corresponding time intervals on opposite sides of the ridge may vary as much as 0.5 cm./year. A partial sequence of Cretaceous and a nearly complete "Keathley" sequence of Late Jurassic magnetic anomalies were identified to a distance east of the Mid-Atlantic Ridge, corresponding to an estimated crustal age of 155 million years.

A systematic survey covering a 34,000-km.^{2} area of the abyssal hills in the eastern central North Atlantic was made with a trackline spacing of 18 km. This investigation revealed two intersecting topographic trends—two fracture zones trending 112° and a ridge-and-trough topography trending 47°. The ridge-and-trough topography is neither orthogonal to the fracture zones nor parallel with the Mid-Atlantic Ridge axis. An analysis of these patterns may allow the stress field on the abyssal floor to be inferred from the strain pattern. The results indicate that in addition to sea floor spreading about a midocean ridge, other processes are active in the development of abyssal hills.

A bottom sampling program was also conducted in 1971 along the eastern extension of the Atlantis Fracture Zone. Measurements include studies of the interstitial water contents and geochemistry of the sediments and petrologic analyses of hard rocks. Outstanding results of the dredging program include the finding of thick manganese encrustations along the entire length of the fracture zone and the dredging of deep-water limestone from the Mid-Atlantic Ridge.

Caribbean Atlantic Geotraverse (CAG). Most of the tracklines for this project were oriented east-west between the Lesser Antilles Arc and the Mid-Atlantic Ridge and were spaced about 36 km. apart. Additionally, several north-south lines were run across the entire "Funnel-Smith" opening, and a detailed grid (8-km. trackline spacing) was established at the western extension of the Barracuda fault (fig. 34).

The main project objectives were to define the plate margins through the identification and correlation of magnetic anomalies, interpretation of gravity and seismic reflection data, and observation of changes of sea floor morphological provinces.

Preliminary analysis of the data suggests: (1) A north-south discontinuity at longitude 53°W. that offsets and separates the northwest-southeast faults of the Mid-Atlantic Ridge province from the mainly east-west faults located directly east of the island arc, (2) a very narrow zone of correlatable magnetic anomalies near the ridge-crest, (3) west-northwest extension of the Barracuda fault, and (4) high utility of the gravity anomalies in detecting fault zones in the area.

In addition it was found that at 12°30'N., 57°05'W., a fault brings a seismic reflector within 200 m. of the sea floor. This reflector apparently represents an ancient sea floor, which becomes flat 30 km. south of this location, where it is overlain by the sedimentary prism deposited by the Amazon and Orinoco Rivers.

World's Seabed Manganese Deposits

On January 20-21, 1972, the Lamont-Doherty Geological Observatory of Columbia University convened a workshop on the world's seabed manganese deposits; topics considered included their distribution, evaluation, growth, and origin. One hundred-fifty executives and scientists from the academic community, Government, and industry participated in the workshop, which included the presentation of 30 research papers and the establishment of several task teams. Among the workshop participants were also scientists and representatives from foreign nations, such as, Canada, France, India, Netherlands, New Zealand, United Kingdom and W. Germany.

At the workshop, Lamont-Doherty scientists presented new world maps showing the distribution of known deposits of manganese nodules. The maps were prepared from information held in the Lamont-Doherty data bank and gathered from other sources, such as RV *Challenger* and *Albatross*, Florida State University, NOAA, and the Scripps Institution of Oceanography. The data were obtained from bottom photographs, and from core, dredge, and grab samples. The maps of manganese distribution were prepared so that they may be used as overlays on maps showing the distribution of other properties, such as bottom current velocity, bottom topography, heat flow, occurrence of nepheloid layer, sedimentation rate, and other seabed properties.

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Living Resources Program

The objective of the Living Resources Program is to provide a scientific foundation for better management and use of the ocean's biological resources. Research efforts will apply advanced methods of the biological, chemical, and physical marine sciences. Projects will identify the scientific and technical resources needed to complete comprehensive ecosystem studies.

The first major project to be initiated under the Living Resources Program is an intensive study of coastal upwelling. This project, the Coastal Upwelling Ecosystem Analysis (CUEA) project, is designed to provide an understanding of the physical and biological processes in coastal upwelling ecosystems, to allow for effective forecasting of the onset, intensity, and extent of this phenomenon.

More than 20 scientists from 12 United States institutions and several foreign countries have been organized into a team that will investigate selected upwelling systems off the west coasts of Africa, Peru, and the United States in a 7- to 8-year program. The focus of the project will be intensive field experiments. Conceptual models created by the physical and biological oceanographers will be verified and upgraded by shipboard experimentation and data acquisition and analysis. Simulation of the overall ecosystem model will provide the framework for the testing of individual hypothesis and design of subsequent field experiments.

Field experiments are planned for the United States west coast in 1973, Northwest Africa in 1974-75, and Peru in 1976-77. Participating U. S. institutions are:

University of Connecticut
Duke University
Florida State University
University of Miami
National Center for Atmospheric Research
Oregon State University
Pacific Oceanographic Laboratory, NOAA
Pennsylvania State University
Scripps Institution of Oceanography
University of Rhode Island
University of Washington
University of Wisconsin
Woods Hole Oceanographic Institution

Appendix

NATIONAL MARINE DATA INVENTORY (NAMDI)* SUMMARIES

In the following data summary, unless stated otherwise, all institutions or activities are U. S. participants in IDOE and all projects are part of the Declared National Program (DNP) in oceanography. Information is given in the following order:

Line 1:
- IDOE grant holder as identified in the following list of abbreviations; platform or vessel used to collect data; cruise number, where applicable; cruise period; and number of days.

Line 2:
- NODC record number; general geographic area as identified in list of abbreviations; extra information in parentheses (NAR = narrative, TC = track chart, S/A = sampling methods and/or analyses, na = not available); chief scientist(s); organization providing support indicated in parentheses, as identified in list of abbreviations; and Marsden squares as shown in chart inside cover.

Line 3:
- Project or expedition.

Line 4:
- Where applicable, supplementary comments; followed by listing of parameters and number of stations or samples.

* See Introduction

LIST OF ABBREVIATIONS

IDOE grant holder:

AOML	Atlantic Oceanographic and Meteorological Laboratories, NOAA
CG	Coast Guard
MIT	Massachusetts Institute of Technology
NMFS	National Marine Fisheries Service, NOAA
NOS	National Ocean Survey, NOAA
OSU	Oregon State University
POL	Pacific Oceanographic Laboratory, NOAA
PRNC	Puerto Rico Nuclear Center
SIO	Scripps Institution of Oceanography
TA&M	Texas A&M University
UA	University of Alaska
URI	University of Rhode Island
USGS	United States Geological Survey
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution

General geographic area:

AR	Arctic
NA	North Atlantic
NEP	Northeast Pacific
SA	South Atlantic

Organizations providing support:

NSF IDOE	National Science Foundation—International Decade of Ocean Exploration program
AEC	Atomic Energy Commission
ONR	Office of Naval Research
PHS	Public Health Service

ENVIRONMENTAL QUALITY PROGRAM

GEOCHEMICAL OCEAN SECTIONS (GEOSECS) STUDY

- WHOI Knorr Cruise 9, August and September 1970, 11 days
- 04541 NA (TC NAR)
  Spencer, D. W. (NSF IDOE) 115
- IDOE, GEOSECS
- NSF Proposal No. P2X0033

Descriptive Oceanography	Stations or Samples
ocean serial station	1
STD	1
oxygen	1
phosphates	1
nitrites	1
trace elements	1
pH	1
alkalinity	1
silicates	1
radioactivity	1
isotope chemistry	1
dissolved gases	1
bathythermograph-expendable (no. of drops)	2
Geology and Geophysics	
suspended sediment	1

STUDIES OF BASELINE DATA, TRANSPORT, AND BIOLOGICAL EFFECTS OF POLLUTANTS IN THE OCEAN

Atlantic Project

- URI Trident Cruise TR-82, May 1970, 9 days
- 06351 NA (na) Swift, E. (NSF IDOE, PHS) 115, 151
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Meteorology	Stations or Samples
atmospheric dust	6

- URI Trident Cruise TR-85, July 1970, 12 days
- 06352 NA (na) Kester, D. (NSF IDOE, PHS) 111, 112, 148, 149, 150
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Meteorology	Stations or Samples
atmospheric dust	4

- URI Trident Cruise TR-90, November and December 1970, 13 days
- 06353 NA (na) Napora, T. (NSF IDOE, PHS) 115, 151
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Meteorology	Stations or Samples
atmospheric dust	3

- URI Trident Cruise TR-95, February 1971, 15 days
- 06354 NA (na) Sturges, W. (NSF IDOE, PHS) 43, 44
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Meteorology	Stations or Samples
atmospheric dust	2

- URI Trident Cruise TR-102, August 1971, 23 days
- 06355 NA AR (na) Kester, D. (NSF IDOE) 149, 150, 151, 183, 184, 185, 219
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
iron	8
manganese	8
copper	8
lead	8
halogenated hydrocarbons	8
nickel	8
sodium	8
aluminum	8
vanadium	8
Meteorology	
atmospheric dust	12
Biology	
lipid analyses	8

- URI Trident Cruise TR-111, February and March 1972, 22 days
- 06357 NA (na) Duce, R. A. (NSF IDOE, ONR) 38, 39, 40, 41, 42, 43
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
trace elements	27
iron	6
manganese	6
copper	6
lead	6
halogenated hydrocarbons	6
nickel	6
sodium	6
aluminum	
Meteorology	
atmospheric dust	16
Geology and Geophysics	
dredge/grab samples	8
cores	3
Biology	
lipid analyses	6

- URI—June to December 1971
- 06356 NA (na) Duce, R. A. (NSF IDOE) 152
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
iron	8
manganese	8
copper	8
lead	8
halogenated hydrocarbons	8
nickel	8
sodium	8
aluminum	8
vanadium	8
Biology	
lipid analyses	8

- WHOI Gosnold Cruise 175, January to April 1971, 112 days
- 04704 NA (NAR TC) Grice, G. (NSF IDOE) 116, 117
- IDOE
- GX28334 North Atlantic Environ. Water Quality Study, collection of biological samples to be used for analyses of manmade pollutants

Biology	Stations or Samples
neuston/pleuston	1
zooplankton	7
pelagic fishes	2
zoobenthos	5

- WHOI **Gosnold** Cruise 176, May 1971, 4 days
- 06358 NA Hulburt, M. (NSF IDOE) 116, 151, 152
- IDOE
- NSF Proposal No. P1X0047, North Atlantic Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
iron	5
manganese	5
copper	5
lead	5
halogenated hydrocarbons	5
nickel	5
sodium	5
aluminum	5
vanadium	5
Biology	
lipid analyses	5

- WHOI **Knorr** Cruise 19 Leg 4, March and April 1971, 8 days
- 04705 NA (NAR TC) Grice, G. (NSF IDOE) 115
- IDOE
- GX28334 North Atlantic Environ. Water Quality Study, collection of biological samples to be used for analyses of manmade pollutants

Biology	Stations or Samples
neuston/pleuston	5
zooplankton	4
invertebrate nekton	4
pelagic fishes	2
zoobenthos	7

- WHOI **Knorr** Cruise 19 Leg 5, April 1971, 14 days
- 04706 NA (NAR TC) Rowe, G. T. (NSF IDOE) 115, 116, 152
- IDOE
- GX28334 North Atlantic Environ. Water Quality Study, collection of biological samples for manmade pollutants, Fitzgerald's zooplankton collected for trace metal analyses, bottom photos not IDOE nor DNP

Geology and Geophysics	Stations or Samples
bottom photography	5
Biology	
zooplankton	41
zoobenthos	22

- WHOI **Atlantis II** Cruise 59 Leg 8, November and December 1970, 29 days
- 04700 NA (TC S/A) Backus, R. (NSF IDOE) 38, 39, 76, 77, 113
- IDOE
- NSF Grant No. GX28334, North Atlantic Environ. Water Quality Study, collection of biological samples to be used in analyses for manmade pollutants.

Biology	Stations or Samples
neuston/pleuston	4
phytoplankton	2
invertebrate nekton	13
pelagic fishes	20

- WHOI **Atlantis II** Cruise 60 Leg 4, April and May 1971, 31 days
- 04701 SA (TC) Scheltema, R. (NSF IDOE) 408, 409, 410, 411, 412, 442, 443
- IDOE
- GX28334 North Atlantic Environ. Water Quality Study, collection of biological samples to be used in analyses for manmade pollutants

Biology	Stations or Samples
zooplankton	24
invertebrate nekton	11
pelagic fishes	19

- WHOI **Atlantis II** Cruise 60 Leg 5, May and June 1971, 30 days
- 04702 SA (TC) Thompson, G. (NSF IDOE) 334, 370, 371, 336, 407, 443
- IDOE
- GX28334 North Atlantic Environ. Water Quality Study, collection of biological samples to be used in analyses for manmade pollutants

Descriptive Oceanography	Stations or Samples
pollution-oil	4
Biology	
zooplankton	19
invertebrate nekton	27
pelagic fishes	26

- WHOI **Atlantis II** Cruise 60 Leg 6, June and July 1971, 29 days
- 04703 NA SA (NAR TC) Thompson, G. (NSF IDOE) 1, 2, 3, 4, 5, 300, 301, 302, 335
- IDOE
- GX28334 North Atlantic Environ. Water Quality Study, collection of biological samples to be used in analyses for manmade pollutants

Biology	Stations or Samples
zooplankton	5
invertebrate nekton	5
pelagic fishes	6

Gulf of Mexico and Caribbean Project

- PRNC **Palumbo** Cruise PA-007, January 1972, 20 days
- 06119 NA (na) Forster, W. O. (NSF IDOE, AEC) 43, 44
- IDOE
- NSF Proposal No. P1X0084, Gulf of Mexico and Caribbean Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
ocean serial station	23
STD	10
oxygen	10
phosphates	10
nitrates	10
nitrites	10
trace elements	23
pH	10
silicates	10
radioactivity	
bathythermograph-mechanical (no. of drops)	20
transparency	9
sea	
sea surface temperature	
pesticide distribution	
pollution-oil	
Meteorology	
surface meteorological observations	
Geology and Geophysics	
dredge/grab samples	7
chemical analysis of sediment	
physical analysis of sediment	
Biology	
zooplankton	8
pelagic fishes	21
demersal fishes	2

- PRNC **Palumbo** Cruise PS-004, November and December 1971, 19 days
- 05607 NA (na) Forster, W.O. (NSF IDOE, AEC) 43, 44, 45, 81, 82
- IDOE
- NSF Proposal No. P1X0084, Gulf of Mexico and Caribbean Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
ocean serial station	23
STD	9
oxygen	9
phosphates	9
nitrates	9
nitrites	9
trace elements	23
radioactivity	9
bathythermograph-mechanical (no. of drops)	8
transparency (no. of obs.)	8
sea	
sea surface temperature	
pesticide distribution	
pollution-oil	
Meteorology	
surface meteorological observations	
Geology and Geophysics	
dredge/grab samples	6
chemical analysis of sediment	
physical analysis of sediment	
Biology	
phytoplankton	3
zooplankton	12
pelagic fishes	15

- TA&M **Alaminos** Cruise 71-A-5, May and June 1971
- 06359 NA (TC) Sackett, W. M. (NSF IDOE, ONR) 46, 81, 82
- IDOE
- NSF Proposal No. P1X0090, Gulf of Mexico and Caribbean Environ. Water Quality Study (chlorinated and other hydrocarbons measured), remainder of cruise collections reported on NAMDI No. 4822 are non-IDOE

Descriptive Oceanography	Stations or Samples
phosphates	
trace elements	
carbon-14	
halogenated hydrocarbons	
Biology	
particulate organic matter	

- TA&M **Alaminos** Cruise 71-A-12 (I), October 1971
- 06360 NA (TC) Sackett, W. M. (NSF IDOE, ONR) 45, 81, 82, 117
- IDOE
- NSF Proposal No. P1X0090, Gulf of Mexico and Caribbean Environ. Water Quality Study (biological samples analyzed for pollutant materials), remainder of cruise collections reported on NAMDI No. 5756 are non-IDOE

Biology	Stations or Samples
particulate organic matter	
zooplankton	

- TA&M **Alaminos** Cruise 71-A-12 (II), October 1971
- 06361 NA (TC) Jeffrey, L. M. (NSF IDOE, ONR) 81, 82, 117
- IDOE
- NSF Proposal No. P1X0090, Gulf of Mexico and Caribbean Environ. Water Quality Study (biological samples analyzed for pollutant materials), remainder of cruise collections reported on NAMDI No. 5757 are non-IDOE

Biology	Stations or Samples
particulate organic matter	

- TA&M **Alaminos** Cruise 71-A-14, November 1971
- 06362 NA (TC) Ichiye, T. (NSF IDOE, ONR) 82
- IDOE
- NSF Proposal No. P1X0090, Gulf of Mexico and Caribbean Environ. Water Quality Study (biological samples analyzed for pollutant materials), remainder of cruise collections reported on NAMDI No. 5759 are non-IDOE

Biology	Stations or Samples
zooplankton	

Pacific Project

- UA **Accna** Cruise 113, May 1971, 9 days
- 05609 NEP (na) Burrell, D. C. (NSF IDOE) 195, 231
- IDOE
- NSF Proposal No. P1X0094, Pacific Environ. Water Quality Study

Biology	Stations or Samples
primary organic production	10
phytoplankton pigment concentration	10
bacteria/other microorganisms	6
phytoplankton	1
zooplankton	1
demersal fishes	1
zoobenthos	1

- UA **Accna** Cruise 114, June 1971, 7 days
- 05610 NEP (na) Burrell, D. C. (NSF IDOE) 197
- IDOE
- NSF Proposal No. P1X0094, Pacific Environ. Water Quality Study (Bering Sea)

Biology	Stations or Samples
phytoplankton	5
zooplankton	5
pelagic fishes	1
demersal fishes	13
zoobenthos	14

- CG **Glacier** Cruise WEBSEC-71, August and September 1971
- 05615 AR (na) Ingham, M. (NSF IDOE) 267, 268
- IDOE
- NSF Proposal No. P1X0094, Pacific Environ. Water Quality Study

Biology	Stations or Samples
phytoplankton	3
zooplankton	5
zoobenthos	1

- OSU **Cayuse** Cruise 07109-F, September 1971, 3 days
- 05653 NEP (na) Cutshall, N. H. (NSF IDOE) 157
- IDOE
- NSF Proposal No. P1X0077, Pacific Environ. Water Quality Study

Descriptive Oceanography	Stations or Samples
radioactivity	29
isotope chemistry	29
Biology	
fish eggs/larvae	6
zoobenthos	2

- OSU **Onar** Cruise Onar 390, December 1971, 2 days
- 05796 NEP (TC) Carpenter, R. (NSF IDOE) 157
- IDOE
- NSF Proposal No. P1X0077, Pacific Environ. Water Quality Study

Geology and Geophysics	Stations or Samples
geological sampling	30

- SIO **Washington** Cruise, February to October 1971, 94 days
- 05795 NEP (NAR) McGown, J. (NSF IDOE) 121, 122, 157, 158, 86, 87, 88, 52, 16, 15, 314, 350, 351, 387, 388, 425, 426, 9, 10
- IDOE, ARIES Legs 3, 4, 8, 9
- NSF Proposal No. P1X0007, Trace Contaminants in Baseline Study,

the biological samples listed were collected for analyses of the listed contaminants

Geology and Geophysics	Stations or Samples
zinc	
arsenic	
mercury	
lead	
selenium	
cadmium	
halogenated hydrocarbons	
Biology	
neuston/pleuston	
zooplankton	
pelagic fishes	

- UW **Thompson** Cruise TT-64, October 1971, 13 days
- 05652 NEP (na) Cutshall, N. H. (NSF IDOE) 157
- IDOE
- NSF Proposal No. P1X0077, Pacific Environ. Water Quality Study

Geology and Geophysics	Stations or Samples
dredge/grab samples	54
Biology	
pelagic fishes	16
zoobenthos	25

ENVIRONMENTAL FORECASTING PROGRAM

MID-OCEAN DYNAMICS EXPERIMENT (MODE)

- URI **Trident** Cruise TR-104, October and November 1971
- 06350 NA (NAR TC S/A) Lambert, Jr. R. B. (NSF IDOE) 79, 80, 115, 116, 152
- IDOE
- NSF Proposal No. P1X0067, MODE-O

Current Measurements	Stations or Samples
current meter	3

- MIT **Trident** Cruise TR-105, November 1971, 17 days
- 05710 NA (TC) Scarlet, R. (NSF IDOE) 79, 80
- MODE-O, IDOE
- NSF Proposal No. P1X0067

Descriptive Oceanography	Stations or Samples
ocean serial station	3
STD	51
sea	
swell	
Meteorology	
surface meteorological observations	

- MIT **Trident** Cruise TR-107, December 1971, 12 days
- 05711 NA (TC) Scarlet, R. (NSF IDOE) 79
- MODE-O, IDOE
- NSF Proposal No. P1X0067

Descriptive Oceanography	Stations or Samples
ocean serial station	56
sea	
swell	
Meteorology	
surface meteorological observations	

NOAA PROJECTS

Ships of opportunity: Time-Series Experimental Bathythermograph Sections, Tropical and North Pacific Ocean

- NMFS **Californian**, August 1969, 5 days
- 05524 NEP (na) Saur, T. (NSF IDOE) 86, 87, 88, 121, 122
- IDOE, XBT-Pacific Ships of Opportunity
- NSF Proposal No. P1X0014

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	29
sea-surface temperature	30
salinity-surface	27

- NMFS **Californian**, November 1970, 6 days
- 05523 NEP (na) Saur, T. (NSF IDOE) 86, 87, 88, 121, 122
- IDOE, XBT-Pacific Ships of Opportunity
- NSF Proposal No. P1X0014

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	28
sea-surface temperature	30
salinity-surface	29

- NMFS **Californian**, November 1970, 15 days
- 05522 NEP (na) Saur, T. (NSF IDOE) 86, 87, 88, 121, 122
- IDOE, XBT-Pacific Ships of Opportunity
- NSF Proposal No. P1X0014

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	33
sea-surface temperature	33
salinity-surface	33

- NMFS **Californian**, December 1970, 5 days
- 05521 NEP (na) Saur, T. (NSF IDOE) 86, 87, 88, 121, 122
- IDOE, XBT-Pacific Ships of Opportunity
- NSF Proposal No. P1X0014

Descriptive Oceanography	Stations or Samples
bathythermograph expendable (no. of drops)	27
sea-surface temperature	27
salinity-surface	27

- NMFS **Californian**, April 1971, 7 days
- 04827 NEP (na) Saur, T. (NSF IDOE) 87, 88, 121, 122
- IDOE, XBT Project
- Proposal No. P1X0014

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	29
sea-surface temperature	37

- NMFS **Oregon Standard**, September and October 1971, 7 days
- 05525 NEP (na) Saur, T. (NSF IDOE) 88, 124, 160, 196
- IDOE, XBT-Pacific Ships of Opportunity
- NSF Proposal No. P1X0014

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	36
sea-surface temperature	36
salinity-surface	36

Near-Surface Circulation Studies

- POL **Oceanographer** Cruise RP-2-71, August 1971, 4 days
- 05491 NEP (na) Halpern, D. (NSF IDOE) 157
- IDOE
- NSF Proposal No. P2X008 Near Surface Circulation Study

Descriptive Oceanography	Stations or Samples
ocean serial station	17
STD	20
bathythermograph-expendable (no. of drops)	9
sea-surface temperature	
temperature	
water pressure	
tension	

Current Measurements	
current meters-cont. time series (no. of days)	33
Meteorology	
surface meteorological observations	
air temperature	
barometric pressure	
wind speed	

- POL Oceanographer Cruise RP-2-71, September 1971, 3 days
- 05492 NEP (na) Halpern, D. (NSF IDOE) 157
- IDOE
- NSF Proposal No. P2X008 Near Surface Circulation Study (bathymetry not part of IDOE)

Descriptive Oceanography	Stations or Samples
ocean serial station	18
STD	18
sea-surface temperature	
Geology and Geophysics	
bathymetry-wide beam (no. of naut. mi.)	40

Air-Sea Interaction and Mixed Layer Project

- AOML Discoverer, September and October 1971, 18 days
- 05542 NA (na) Ostapoff, F. (NSF IDOE) 79
- IDOE, Mixed Layer Project

Descriptive Oceanography	Stations or Samples
STD	30
bathythermograph-expendable (no. of drops)	578
Meteorology	
upper air observations	30
surface meteorological observations	393
incident radiation	
Other	
current profiles	92
temperature readings from two instrumented buoys	70,000

Circulation Studies-CICAR

- AOML Discoverer Cruise RP-9-71, July to August 1971, 42 days
- 05605 NA (TC) Starr, R.B. (NSF IDOE) 44, 45, 80, 81
- IDOE/CICAR/EGMEX IV
- Circulation Studies

Descriptive Oceanography	Stations or Samples
STD	87
oxygen	87
total phosphorus	87
nitrates	87
nitrites	87
trace elements	39
pH	39
silicates	87
bathythermograph-expendable (no. of drops)	336
tides	
sea surface temperature	
Current Measurements	
current meters-cont. time series (no. of days)	30
surface drifters (no. released)	656
current meter	2
Meteorology	
surface meteorological observations	
Geology and Geophysics	
bathymetry-narrow beam (no. of naut. mi.)	51,759
Biology	
zooplankton	16
fish eggs/larvae	70

- AOML Discoverer Cruise RP-11-71, September and October 1971, 44 days
- 05538 NA (na) Ostapoff, F./Hansen, D. 43, 44, 79, 80
- CICAR/IDOE-Deep Sea Tide and Mixed Layer Project
- NSF Proposal No. P2X0014

Descriptive Oceanography	Stations or Samples
STD	22
oxygen	16
trace elements	10
bathythermograph-expendable (no. of drops)	75
sea-surface temperature	
deep sea tide	
Current Measurements	
current meter	2
drift bottles/cards	33
Meteorology	
surface meteorological observations	

- AOML Researcher Cruise RP-9-7/CSM-1, July to September 1971, 51 days
- 05594 NA (TC S/A) Molinari, R. L. (NSF IDOE) 45, 81
- IDOE/CICAR
- Circulation Studies

Descriptive Oceanography	Stations or Samples
ocean serial station	35
STD	80
bathythermograph-expendable (no. of drops)	403
bathythermograph-mechanical (no. of drops)	264
sea	
swell	
sea-surface temperature	
radioactivity-surface	87
copper	87
Current Measurements	
drogues	
Meteorology	
surface meteorological observations	
Geology and Geophysics	
gravity (no. of naut. mi.)	3,240
magnetic (no. of naut. mi.)	3,240
bathymetry	7,000

SEABED ASSESSMENT PROGRAM

SURVEYS AND DATA ANALYSIS

USGS Unitedgeo I Surveys

Leg 1, Bay of Campeche

- USGS Unitedgeo I May and June 1971, 22 days
- 04699 NA (na) Moore, G. W. (NSF IDOE) 46, 82
- USGS-IDOE Leg I (Campeche) 1971
- NSF Proposal No. P1X0019 Corpus Christi to Veracruz, a Geophysical-Traverse Chart for this cruise Leg on which the positions of dredge hauls, XBT drops, and refraction profiles have been annotated is on file at NGSDC.

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	5
Geology & Geophysics	
dredge/grab samples (no. of samples)	1
seismic-reflection profiles (no. of naut. mi.)	3,800

seismic-refraction profiles	2
gravity (no. of naut. mi.)	3,800
magnetic (no. of naut. mi.)	3,800
bathymetry-wide beam (no. of naut. mi.)	3,800

Leg 2, East Margin Yucatan Peninsula

- USGS **Unitedgeo I,** USGS-UGEO Cruise 71-2, June and July 1971, 26 days
- 04789 NA (NAR) Vedder, J. G. (NSF IDOE) 45, 46, 81, 82
- IDOE
- NSF Proposal No. P1X0019

Descriptive Oceanography	**Stations or Samples**
bathythermograph-expendable (no. of drops)	3
Geology & Geophysics	
dredge/grab samples (no. of samples)	7
seismic-relection profiles (no. of naut. mi.)	2,400
gravity (no. of naut. mi.)	2,800
magnetic (no. of naut. mi.)	2,800
bathymetrywide beam (no. of naut. mi.)	2,400
sediment thermal gradient	1

Leg 3, Eastern Greater Antilles

- USGS **Unitedgeo I** USGS-IDOE Cruise 71, Leg 3 Greater Antilles, July and August 1971, 19 days
- 05429 NA (NAR) Garrison, L. E. (NSF IDOE) 42, 43
- IDOE
- NSF Proposal No. P1X0019

Geology & Geophysics	**Stations or Samples**
dredge/grab samples (no. of samples)	1
seismic-relection profiles (no. of naut. mi.)	3,028
seismic-refraction profiles	3
gravity (no. of naut. mi.)	3,028
magnetic (no. of naut. mi.)	3,028
bathymetry-wide beam (no. of naut. mi.)	3,028

Leg 4, Venezuela Continental Borderland

- USGS **Unitedgeo I,** USGS-IDOE Cruise 71, Leg 4, Venezuelan Borderland, August to October 1971, 45 days
- 05490 NA (NAR) Silver, E. A. (NSF IDOE) 43, 44
- IDOE
- NSF Proposal No. P1X0019

Geology & Geophysics	**Stations or Samples**
seismic-reflection profiles (no. of naut. mi.)	4,200
gravity (no. of naut. mi.)	4,200
magnetic (no. of naut. mi.)	4,200
bathymetry-wide beam (no. of naut. mi.)	4,200
seismic reflection profiles (sonobuoy)	2
Biology	
aves	

Leg 5, Continental Margin of Liberia

- USGS **Unitedgeo I,** UG-1, Leg 5, October and November 1971, 23 days
- 05871 NA (TC NAR) Schlee, J. S. (NSF IDOE) 1, 2
- IDOE
- NSF Proposal No. P1X0019, Geophysical/Geological Investigation of West Africa (Liberian Continental Margin)

Geology & Geophysics	**Stations or Samples**
dredge/grab samples (no. of samples)	3
seismic-reflection profiles (no. of naut. mi.)	2,911
gravity (no. of naut. mi.)	2,911
magnetic (no. of naut. mi.)	2,911
bathymetry-narrow beam (no. of naut. mi.)	2,911
seismic reflection profiles (sonobuoy)	5

Leg 6, Trans-Atlantic Crossing, West Africa to Virgin Islands

- USGS **Unitedgeo I,** Leg 6, November and December 1971, 16 days
- 05909 NA (TC NAR) Kane, M. F. (NSF IDOE) 2, 3, 4, 5, 40, 41, 42, 43
- IDOE
- NSF Proposal No. P1X0019

Geology & Geophysics	**Stations or Samples**
seismic-reflection profiles (no. of naut. mi.)	3,050
seismic-refraction profiles	18
gravity (no. of naut. mi.)	3,400
magnetic (no. of naut. mi.)	3,400
bathymetry-wide beam (no. of naut. mi.)	3,400

NOAA Surveys and Data Analysis

Pacific SEAMAP

- NOS **Surveyor** Cruise OPR 421, June to November 1971, 170 days
- 05700 NEP (na) Elvers, D. J. (NSF IDOE) 157, 158, 159
- SEAMAP IDOE
- NSF Grant AG 253, Seabed Assessment

Descriptive Oceanography	**Stations or Samples**
bathythermograph-expendable (no. of drops)	357
Geology & Geophysics	
seismic-reflection profiles (no. of naut. mi.)	7,323
gravity (no. of naut. mi.)	36,592
magnetic (no. of naut. mi.)	36,877
bathymetry-narrow beam (no. of naut. mi.)	37,118

Trans-Atlantic Geotraverse (TAG)

- AOML **Discoverer** Cruise TAG, April to June 1971, 73 days
- 04698 NA (na) Rona, P. A. (NSF IDOE) 74, 75, 76, 77
- IDOE
- Trans-Atlantic Geotraverse

Descriptive Oceanography	**Stations or Samples**
ph	62
alkalinity	55
Geology & Geophysics	
dredge/grab samples (no. of samples)	27
cores (no. of cores)	12
seismic-reflection profiles (no. of naut. mi.)	808
gravity (no. of naut. mi.)	14,140
magnetic (no. of naut. mi.)	14,333
bathymetry-narrow beam (no. of naut. mi.)	15,115
seismic reflection profiles (sonobuoy)	8
Biology	
plankton	12

Caribbean-Atlantic Geotraverse (CAG)

- AOML **Researcher** Cruise RP-12-71, September to November 1971, 52 days
- 05620 NA (TC) Peter, G. (NSF IDOE) 41, 42, 43, 79, 80
- IDOE/CICAR
- NSF Proposal No. P1X0007, Ocean Basin Geol.-Atl.-Caribbean Geotrav., bottom and interstital material were sampled for pH and alkalinity

Descriptive Oceanography	Stations or Samples
bathythermograph-expendable (no. of drops)	6
Current Measurements	
surface drifters (no. released)	10
current meter	3
Geology & Geophysics	
seismic-reflection profiles (no. of naut. mi.)	1,700
gravity (no. of naut. mi.)	18,050
magnetic (no. of naut. mi.)	18,200
bathymetry-wide beam (no. of naut. mi.)	7,900
bathymetry-narrow beam (no. of naut. mi.)	10,300

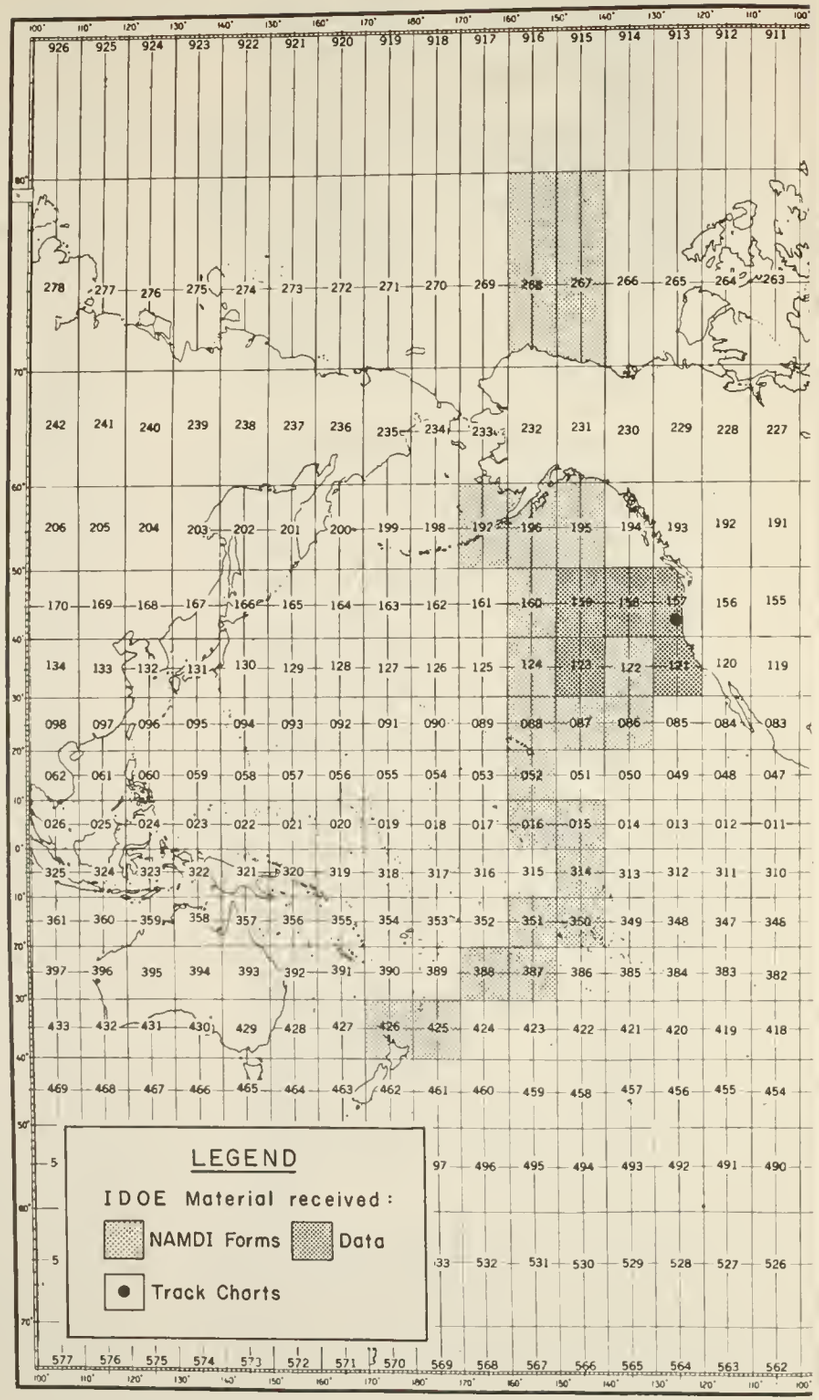

Chart of Marsden Square (10° x 10°) areas within which were collected data and information reported in this publication and received by EDS.

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